The Engineer

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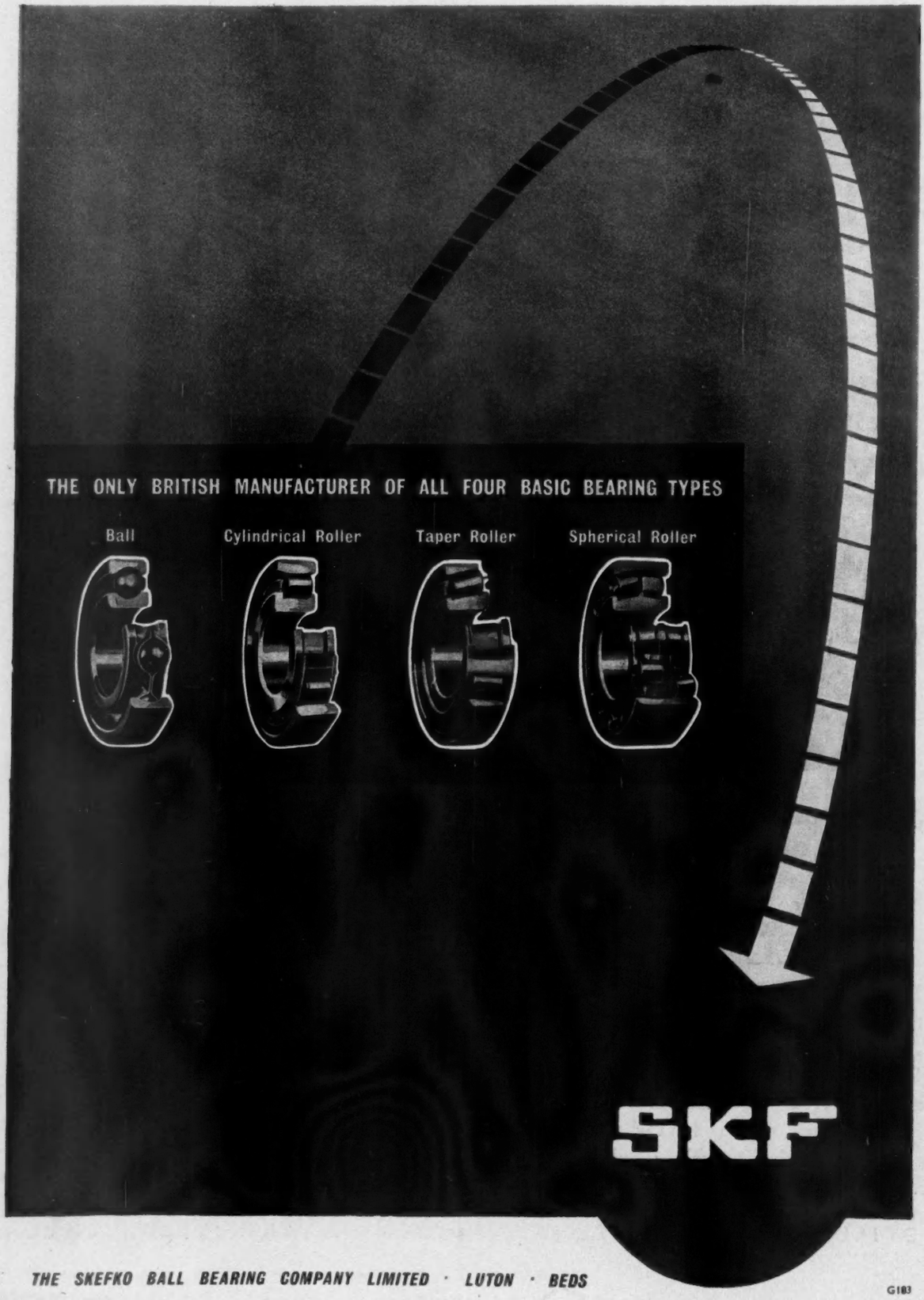

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THE ENGINEER

Established 1856

No. 5347 JULY 18, 1958 VOL. 206

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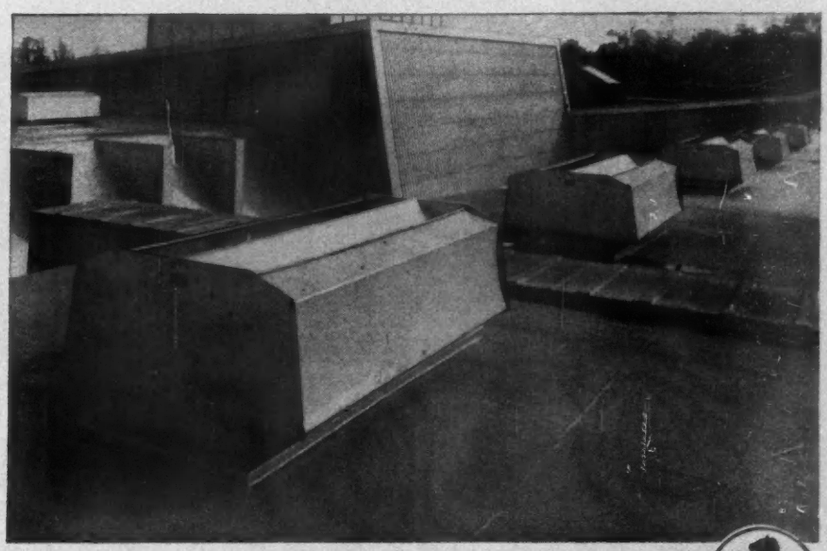

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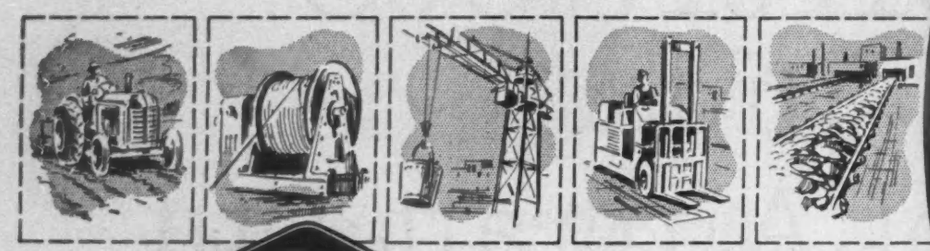

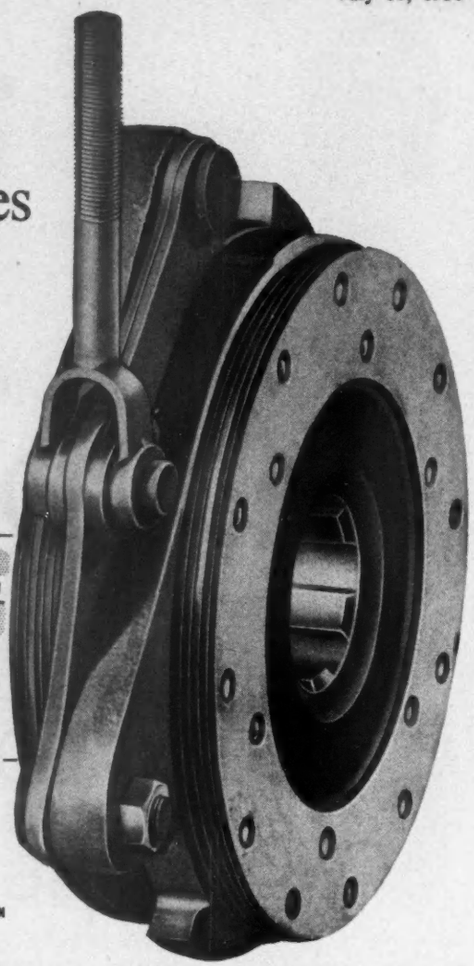

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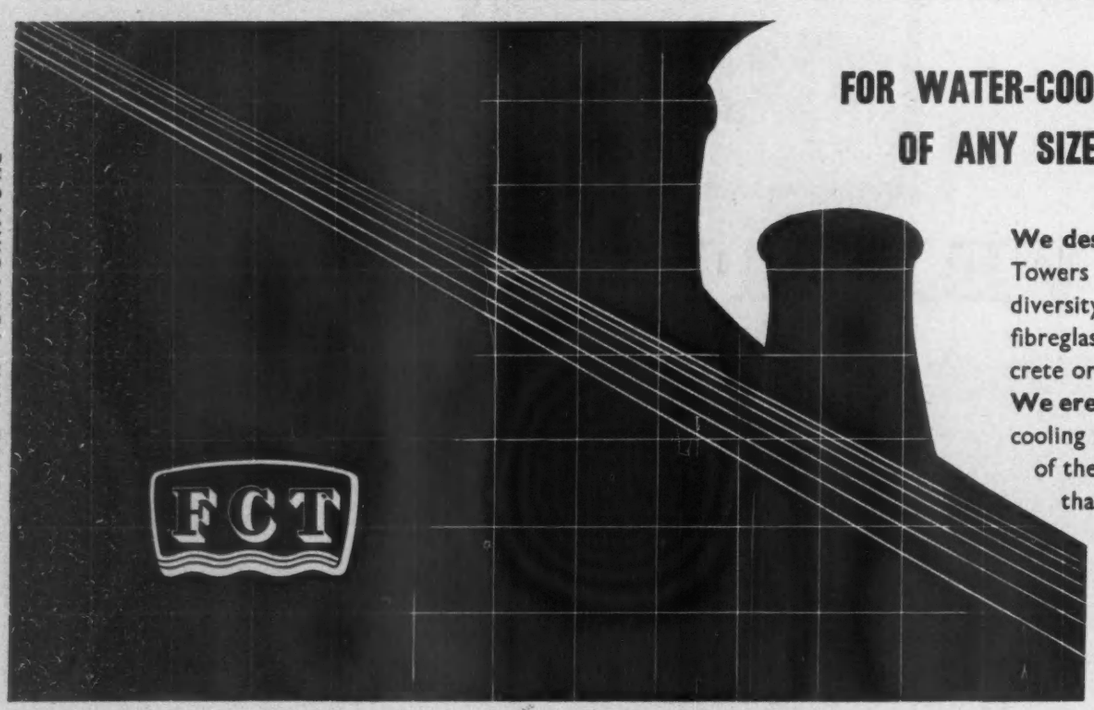

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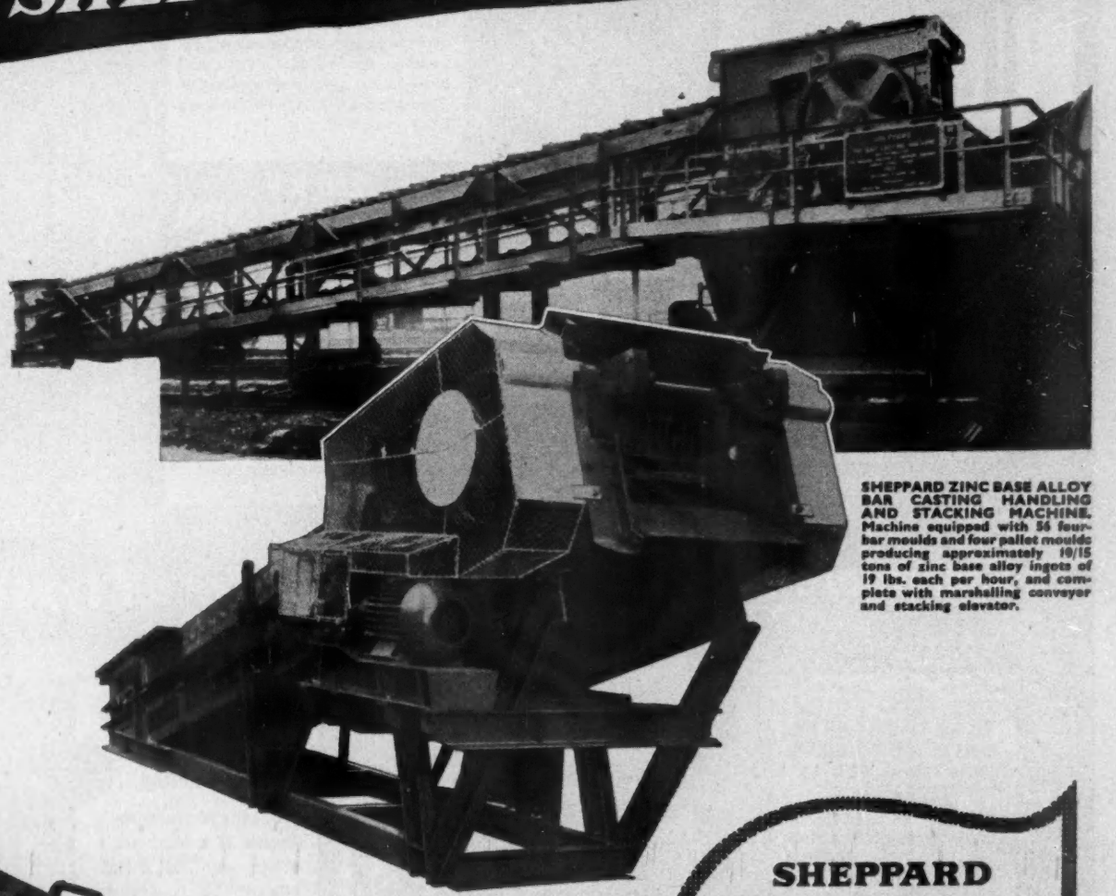

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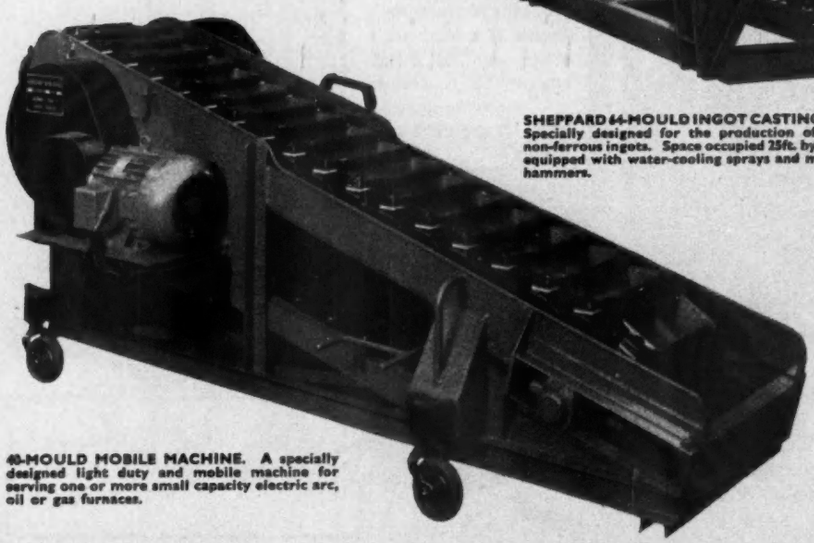

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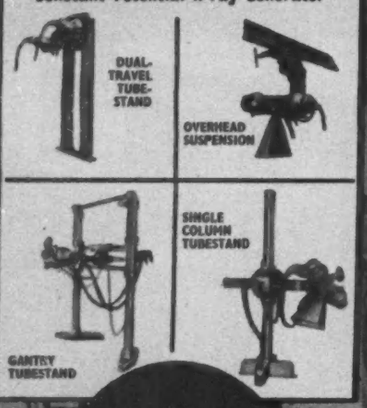
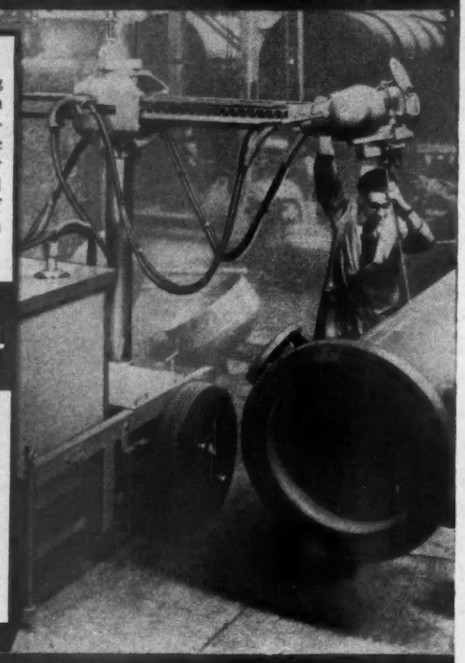


Let Marconi Engineers assist you in your choice of mounting

(Left) — Attached to the Extending Suspension Mounting running on overhead rails, the Marconi Tubehead can be manipulated with ease over the largest components as, for instance, the one-piece cast steel bogie shown. (Photo by courtesy of English Steel Castings Corporation Ltd.)

250 k V CONSTANT POTENTIAL X-RAY EQUIPMENT

(Right)—The Self-propelled Mobile Mounting can be manoeuvred about the shop floor, enabling large components to be inspected without disturbing the flow of production. (Photo by courtesy of W. J. Fraser & Co. Ltd., Chemical Engineers)



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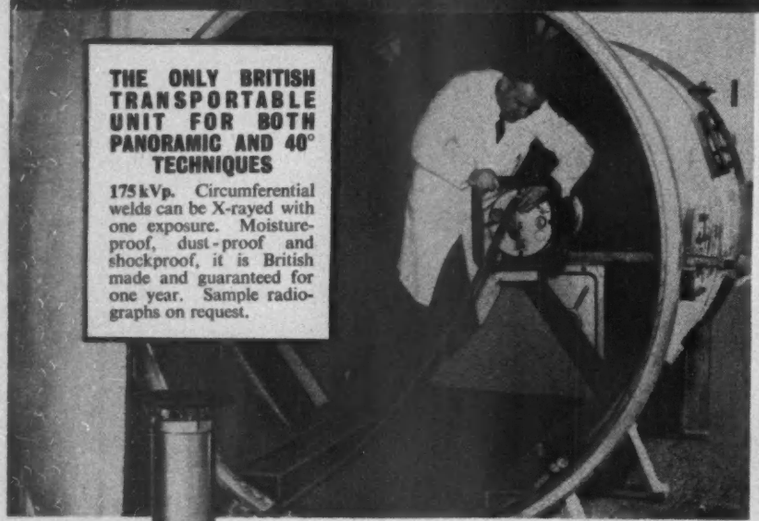

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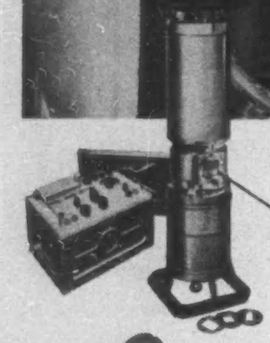

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IX 20

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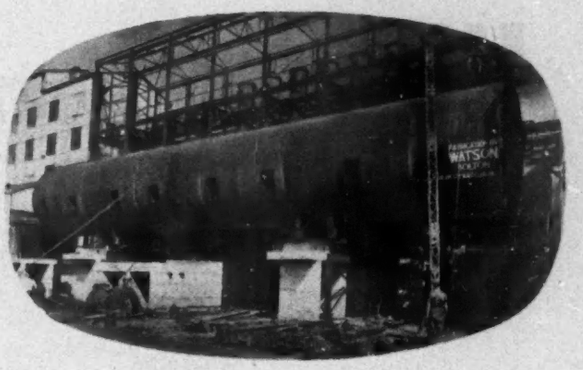

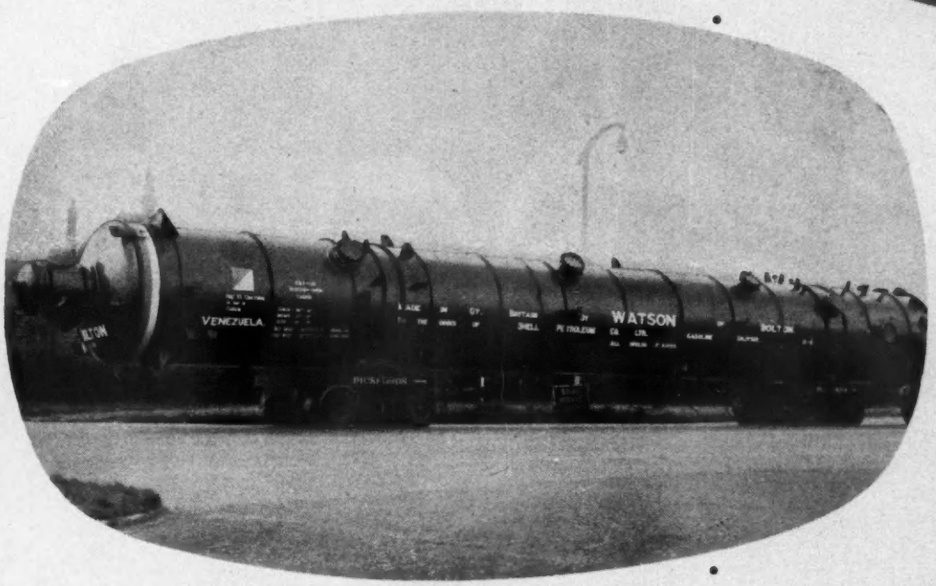

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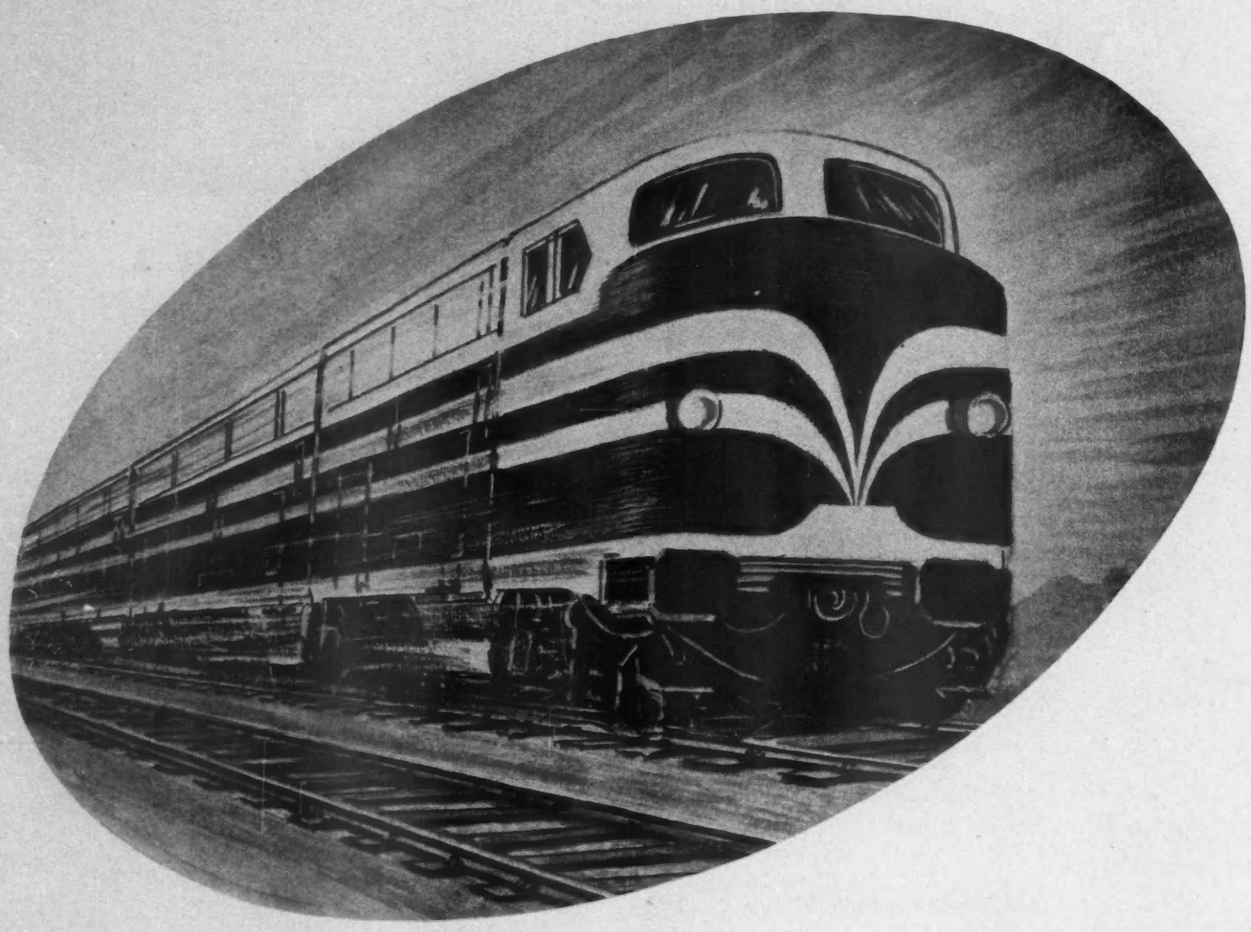

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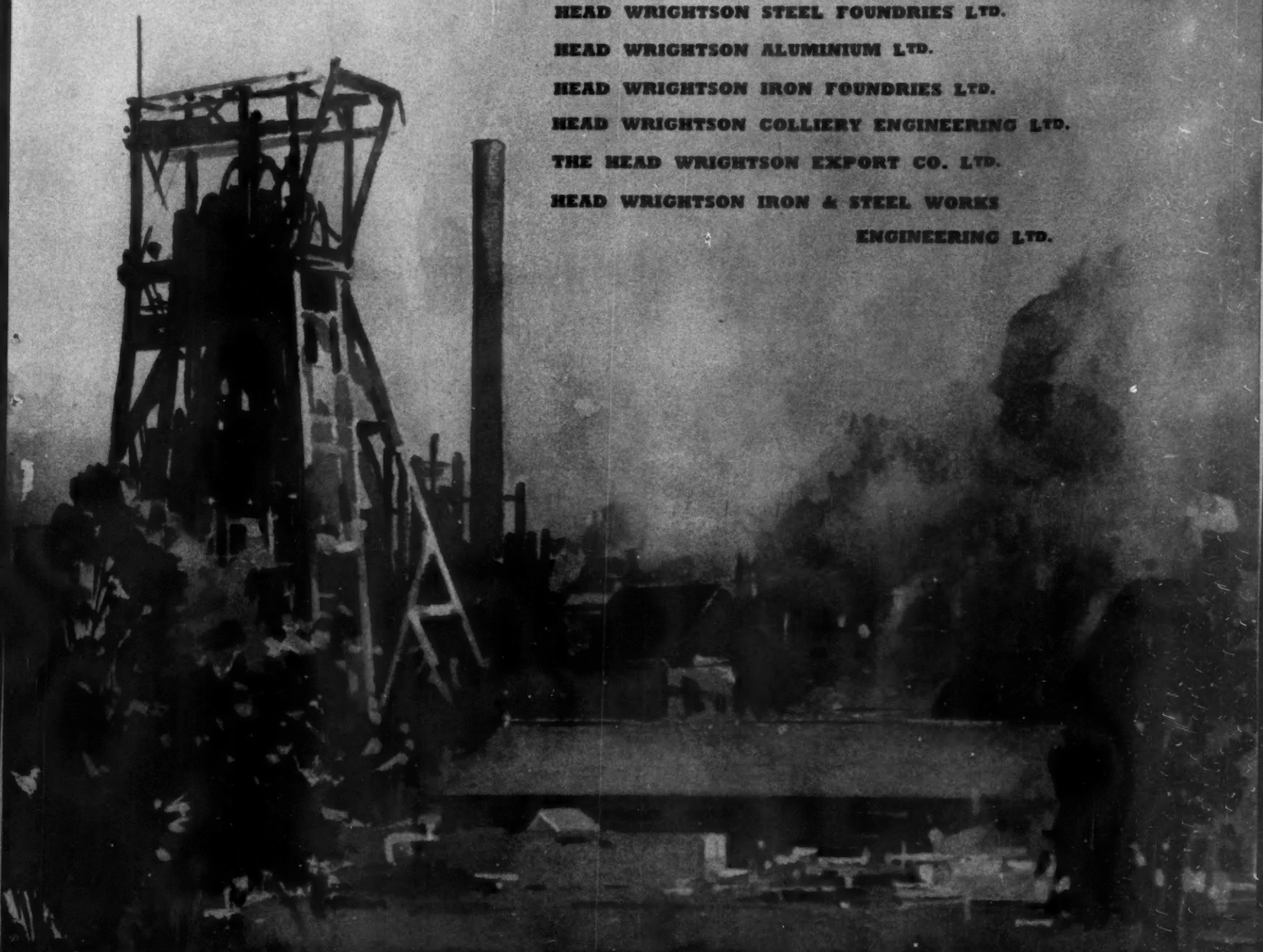

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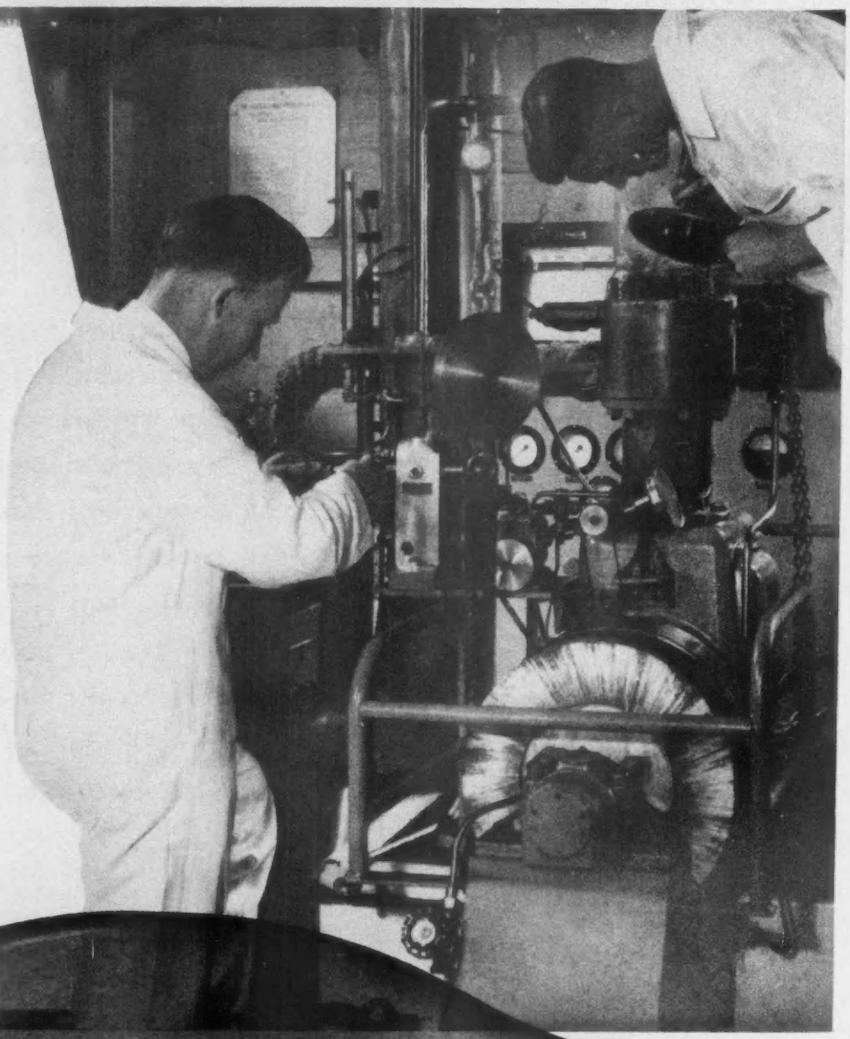

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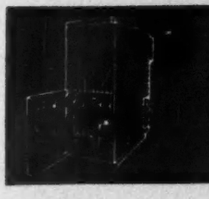

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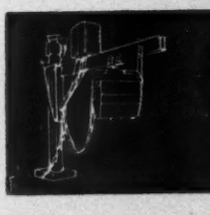

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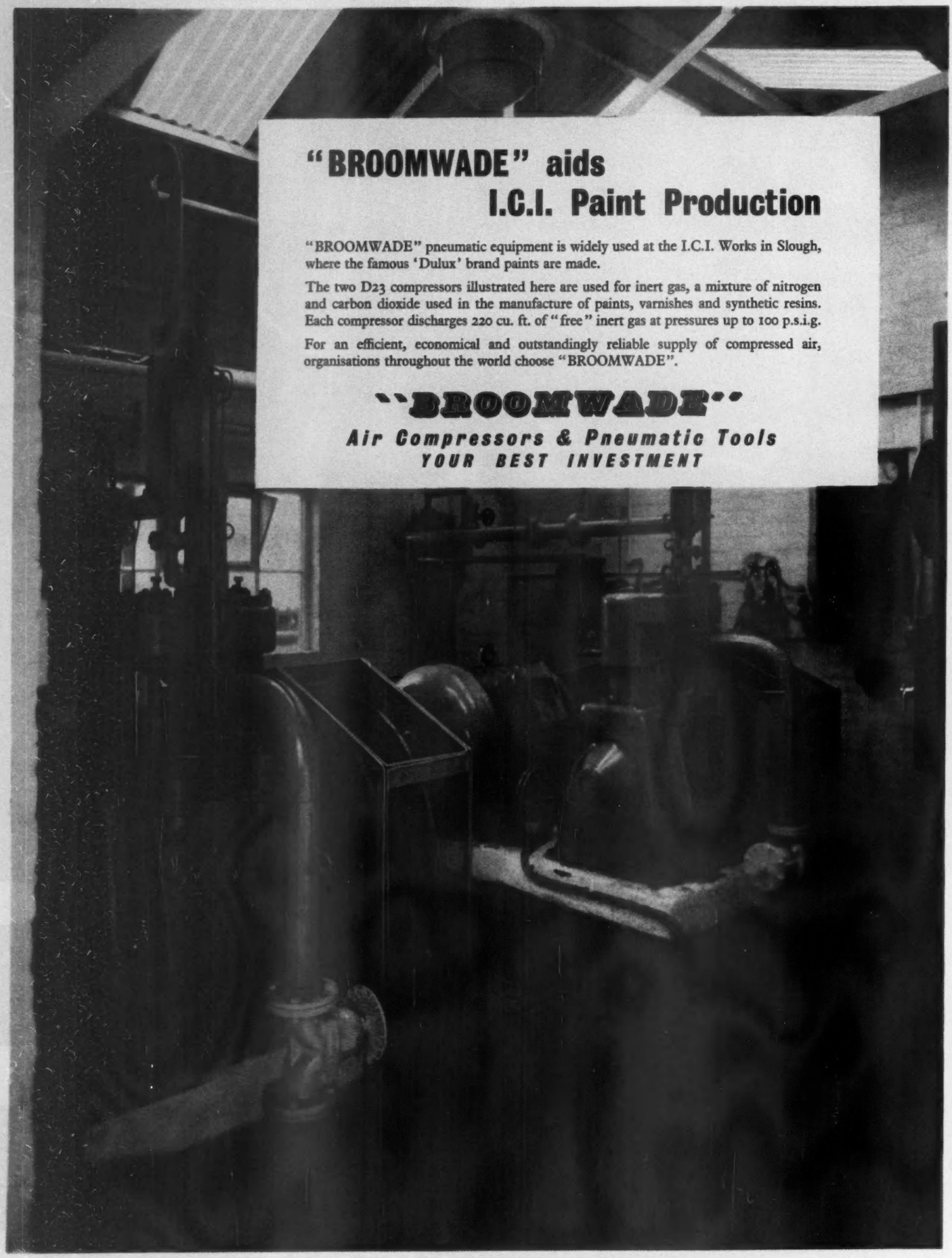

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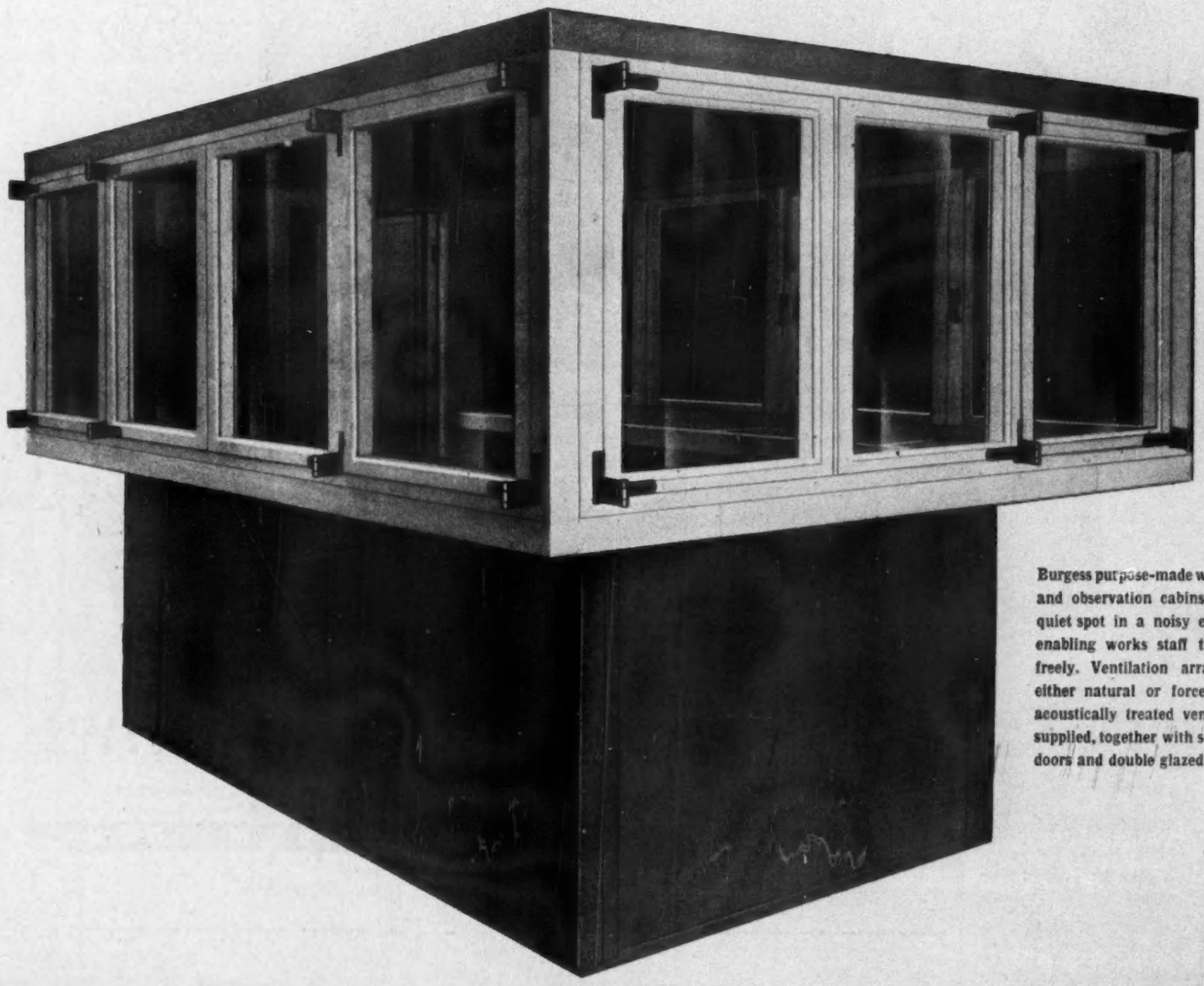

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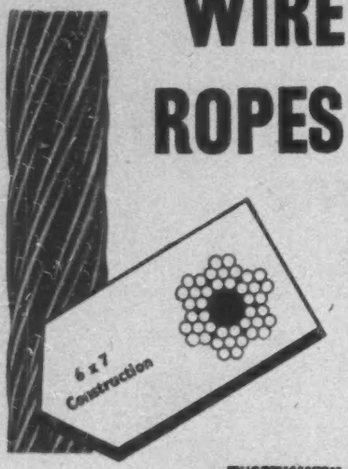

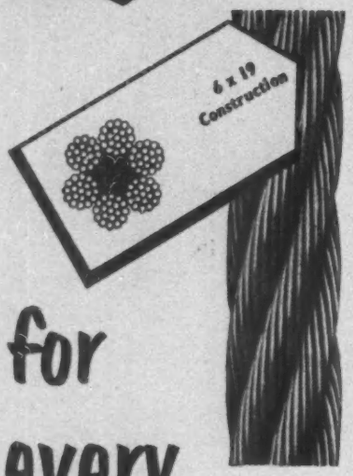

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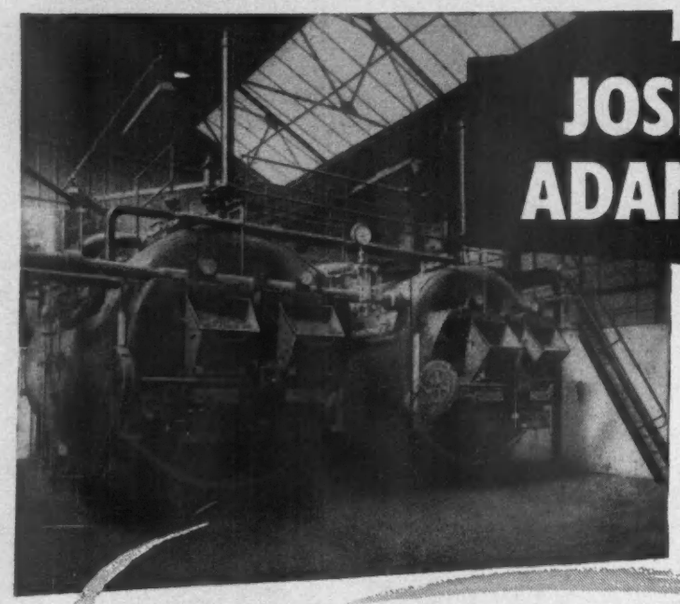

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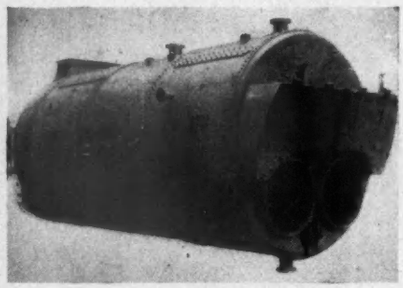

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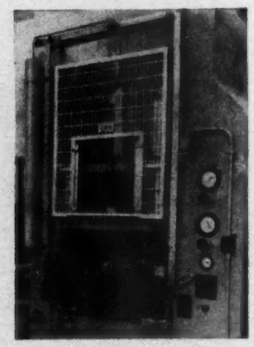
The illustration shows an interlock guard in use on a hydraulic press producing engine components.

For further information please write for leaflet No. 28.



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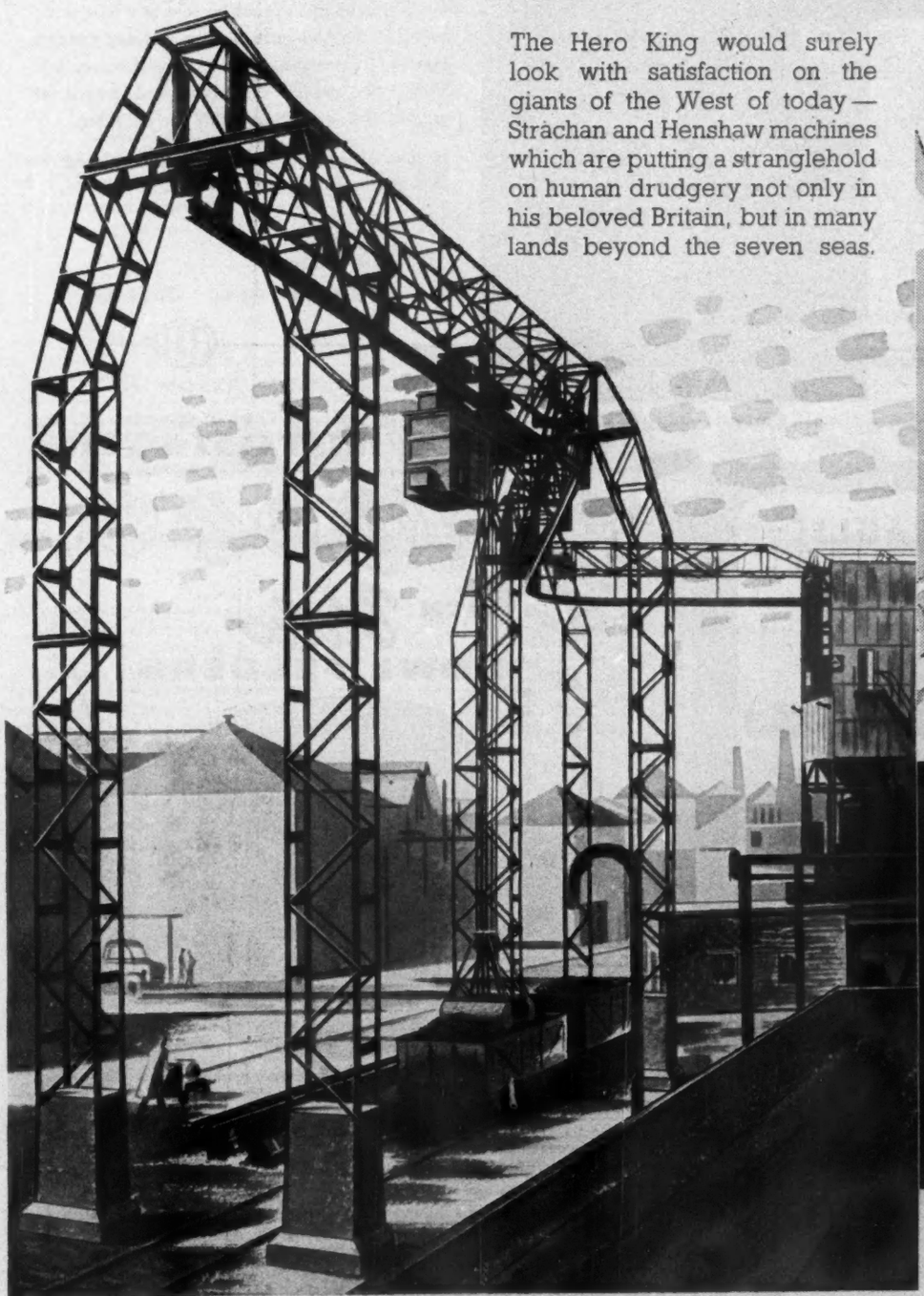
Giants of the West

According to an ancient MS King Arthur himself was no mean giant — "fifteen foote longe in the prime of his yers" — and when tidings were brought that an alien giant — from Spain — had carried off a local pin-up girl called Helen, the King strode off to investigate. At the foot of St. Michael's Mount he found the remains of knightly would-be rescuers. Climbing the Mount, he confronted the oversize Spaniard in the horrid act of eating a man whole. In the tremendous battle that followed Arthur took the blows of the other giant's iron club on his shield, and with his sword Excalibur struck off the swarthy head.

The Hero King would surely look with satisfaction on the giants of the West of today — Strachan and Henshaw machines which are putting a stranglehold on human drudgery not only in his beloved Britain, but in many lands beyond the seven seas.



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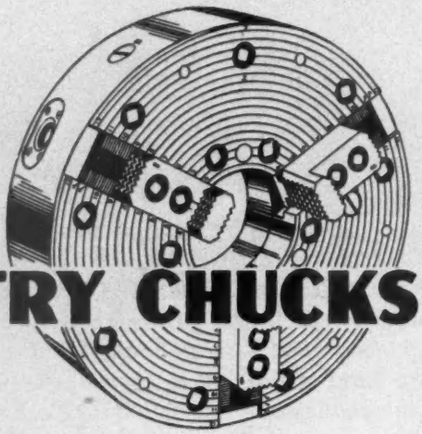

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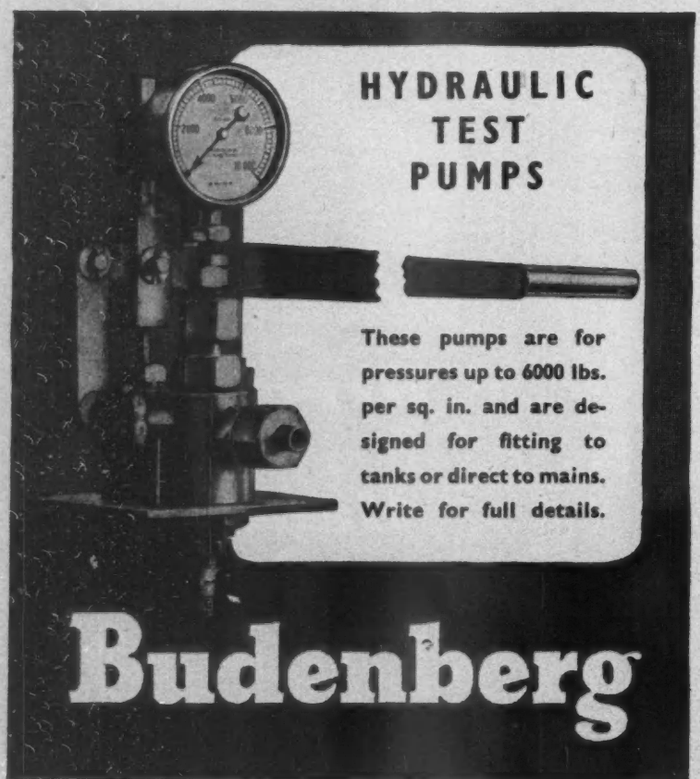

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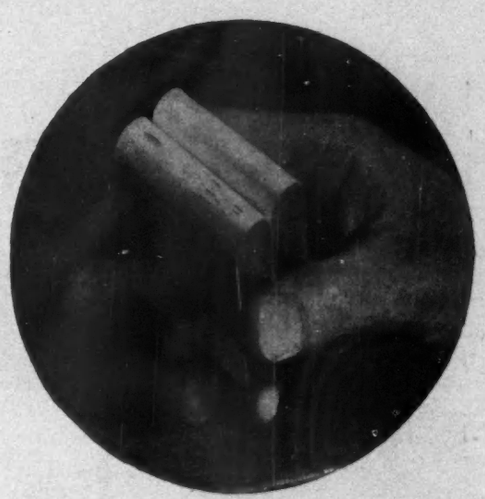

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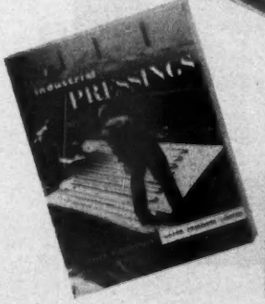

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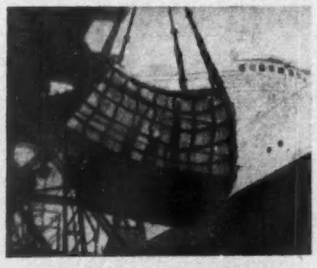

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Last year over one million dollars' worth of Sumo pumps were sold in the highly competitive U.S. market. Here a consignment is being loaded into the Queen Mary at Southampton Docks.

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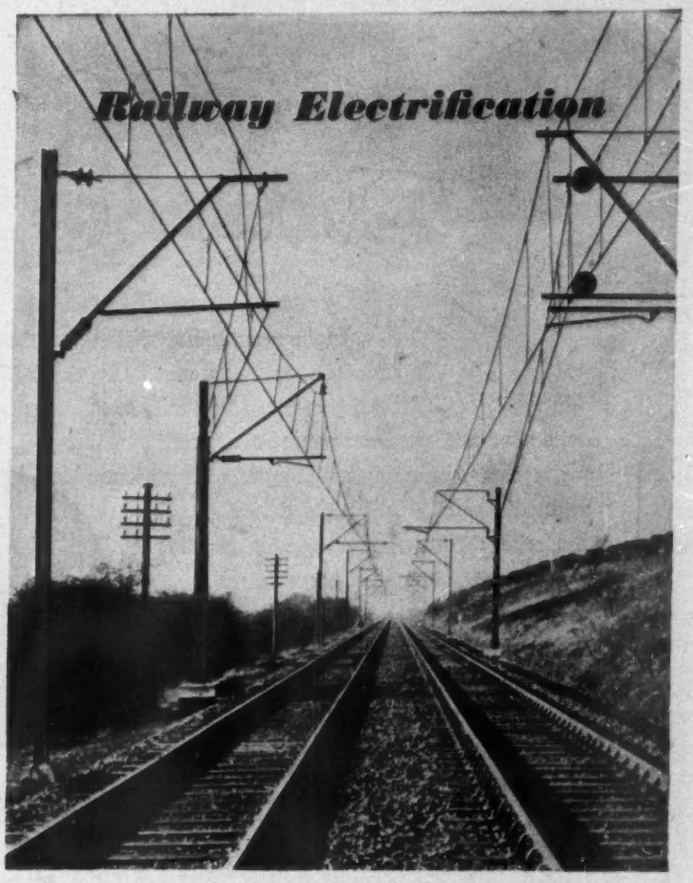

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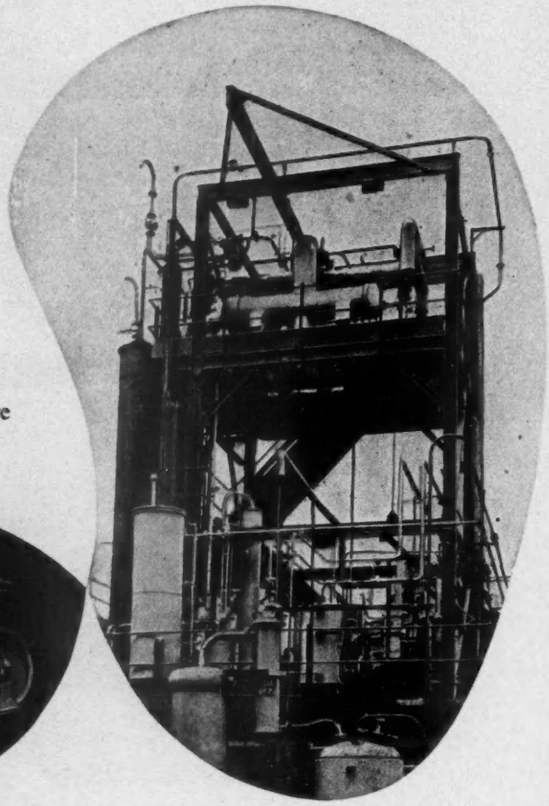

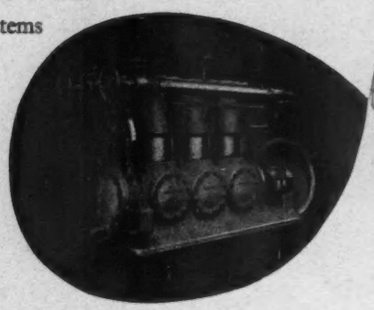

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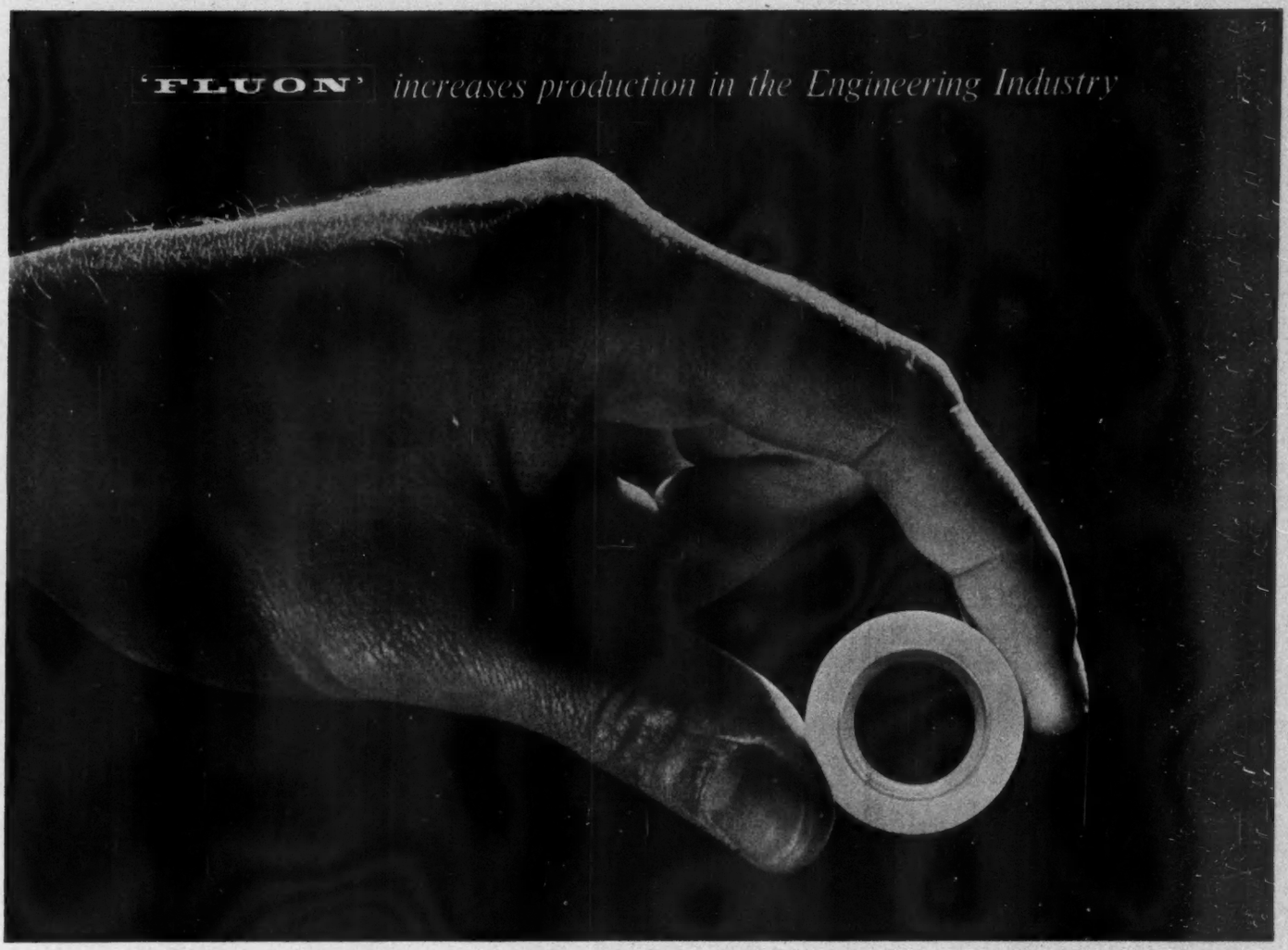
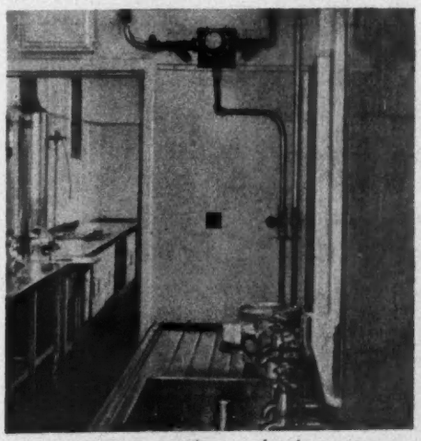


Steam valve seat made of 'Fluon' p.t.f.e. by MEYNELL AND SONS LTD., WOLVERHAMPTON, *taken from a valve which opens and shuts against 80 p.s.i. some 5,000 times a week. (Actual size ⅝")*

'Fluon' p.t.f.e. used for seats in steam/water valves



MEYNELL AND SONS *steam/water valves in a canteen.*

In a canteen kitchen steam/water heater valve that opens and shuts 100 times an hour, 8 hours a day, six or seven days a week, the valve seat is made of 'Fluon' p.t.f.e. 'Fluon' was chosen by the makers, MEYNELL AND SONS LTD., WOLVERHAMPTON, because it is unaffected by temperatures up to 250°C. and because of its exceptional non-stick properties. Furthermore, 'Fluon' is one of the most chemically inert materials known. With few exceptions it is neither attacked by nor will it contaminate or taint other substances with which it comes into contact. This makes it ideal, as in this case, for use near or with food.

'FLUON'

'Fluon' is the registered trade mark for the polytetrafluoroethylene manufactured by I.C.I.

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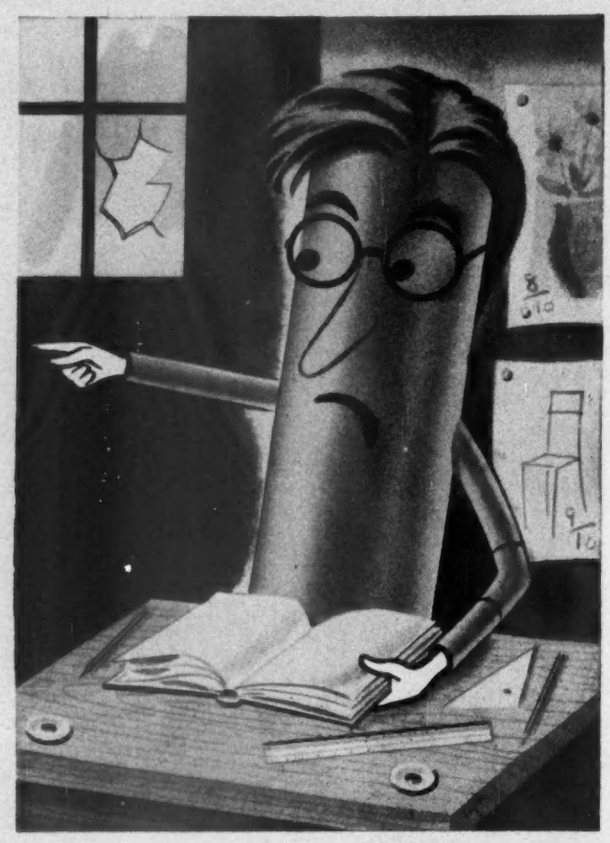
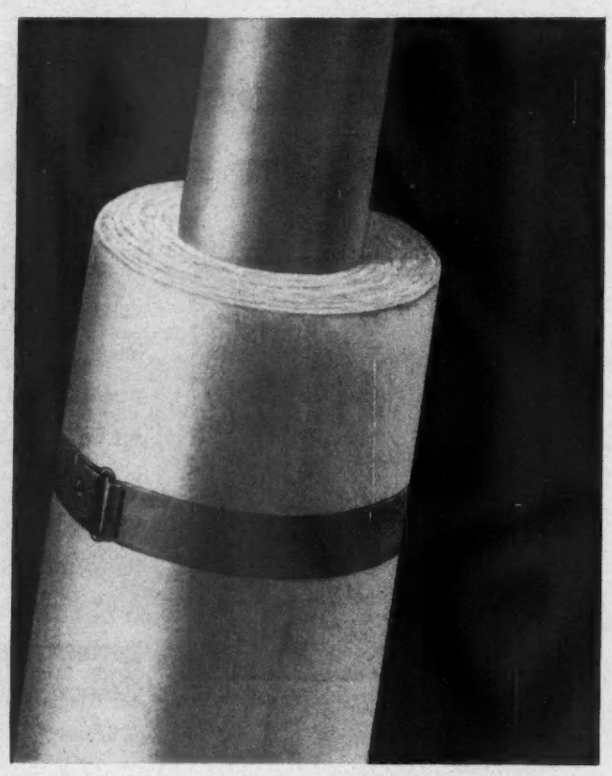
"I WAS A SNEAK"

—*Master H. W. Pipe owns up*



I was always in hot water—or rather, hot water was always in me—when I left the boiler-room. But then I wandered about the school, improperly dressed. I used to dissipate my heat in draughty corridors. By the time I reached the dorm' radiators, I was as tepid as school tea!

But now I'm the blue-eyed boy: from outlet to delivery, I'm clad in Fibreglass Rigid Sections. So delightfully light, so superbly trim—no bagging at the knees and no losing degrees! My behaviour as a saver of fuel and a deliverer of hot water is earning A-plus Reports from all. But I'm *not* expecting a prize for Good Conduct. Because my Fibreglass jacket is about the world's poorest Conductor—of heat anyway!



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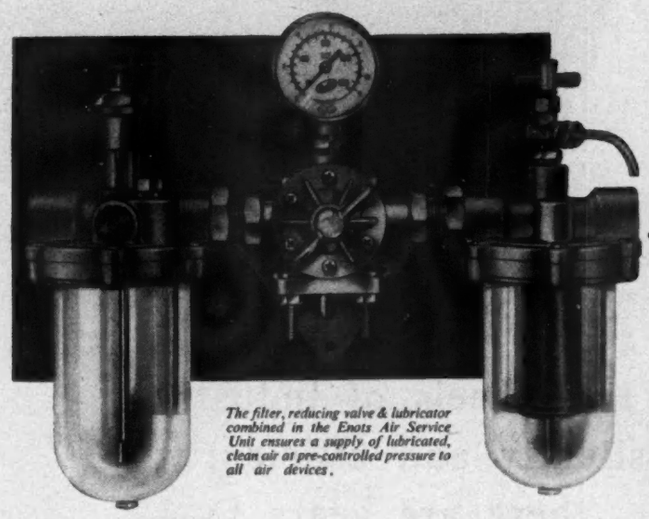

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This man is saving money

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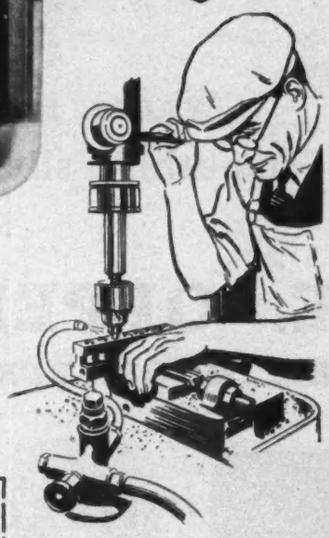

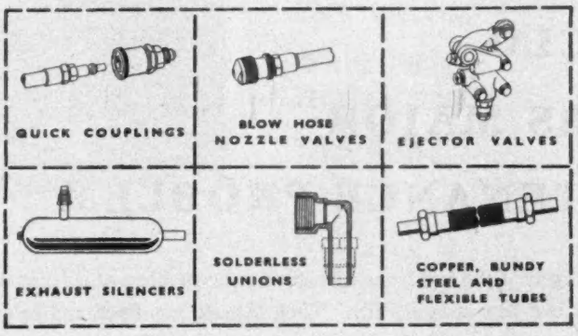

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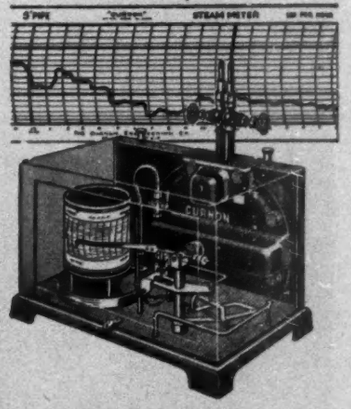

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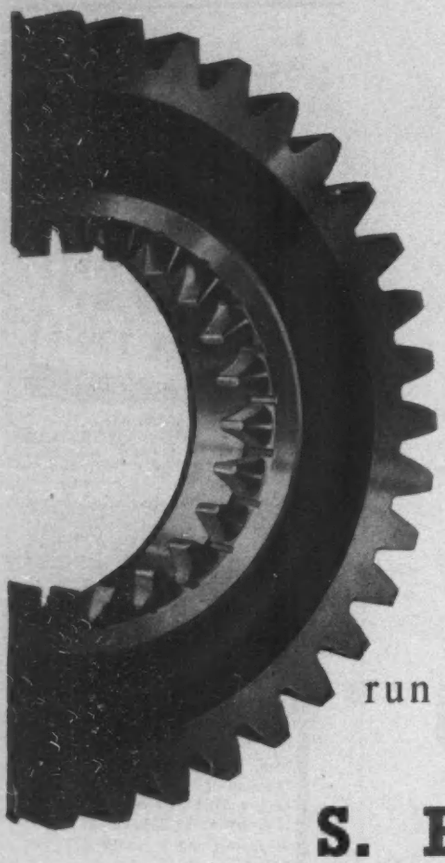

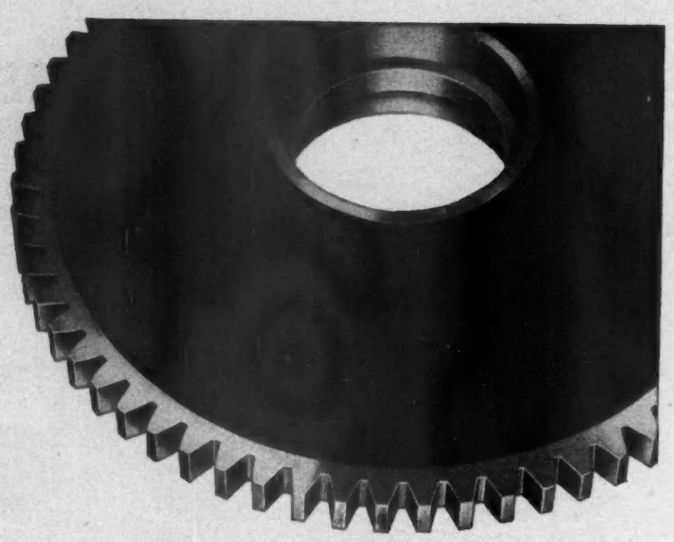

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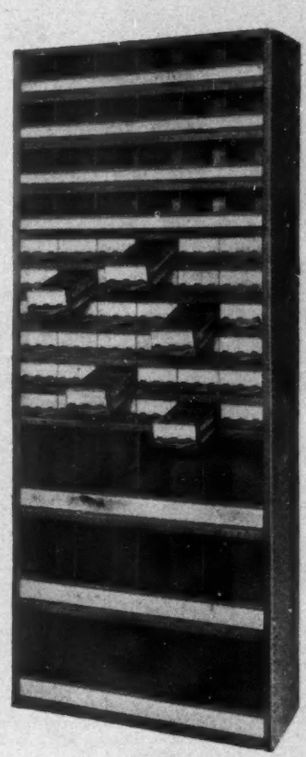

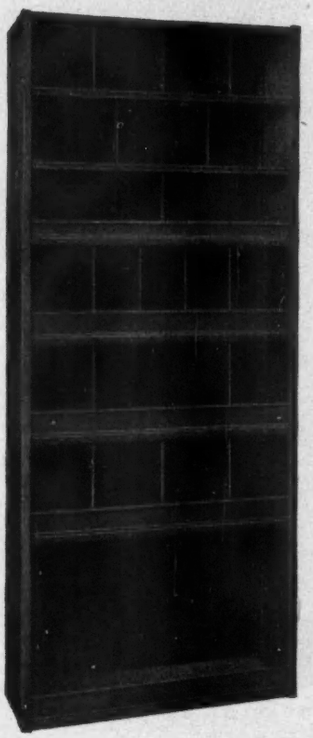

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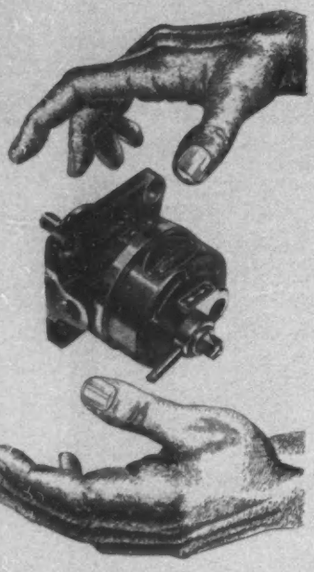

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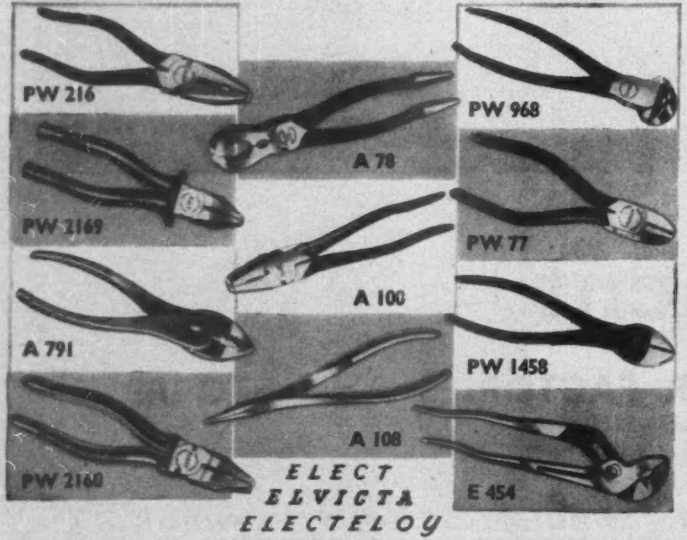

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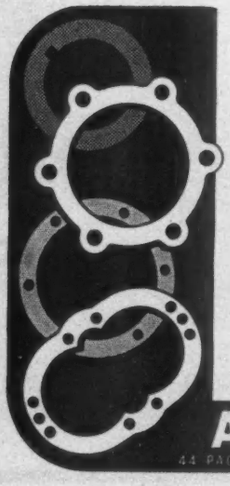

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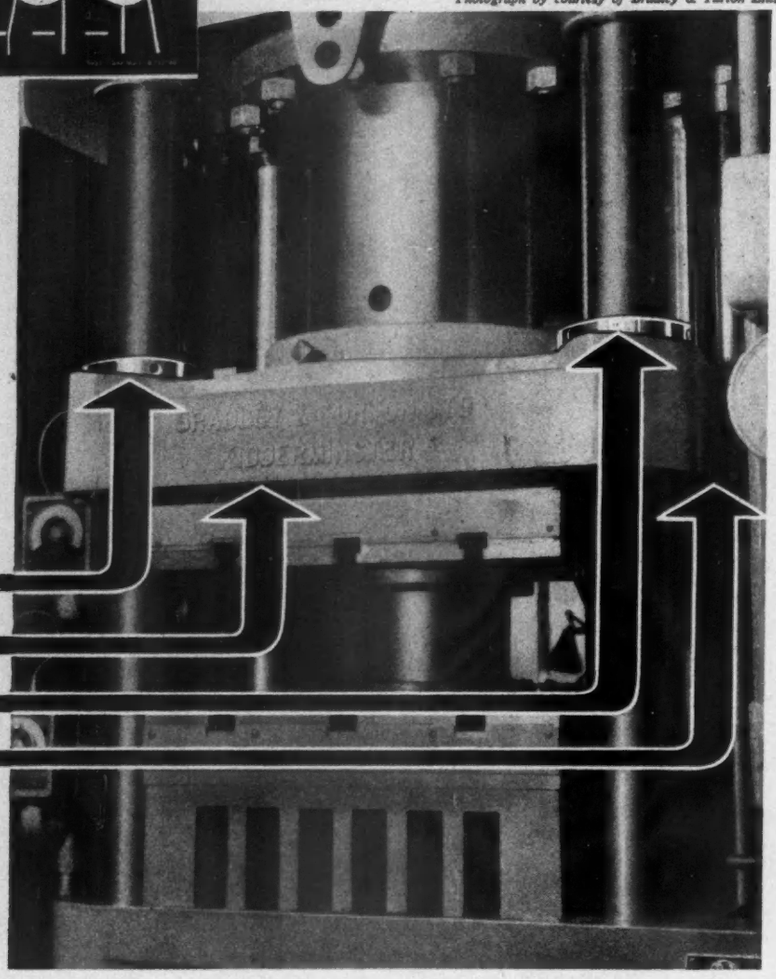
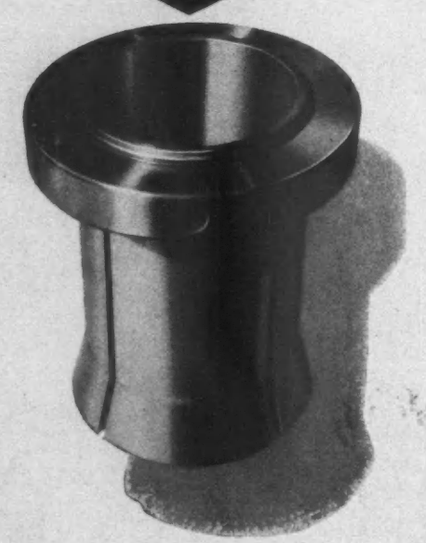


ALZEN 305 IS USED FOR THE RAMHEAD ADJUSTABLE GUIDE BUSH IN THIS 150 TON SELF-CONTAINED SEMI-AUTOMATIC HYDRAULIC PRESS



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THE STEEL TUBE AGE

This artist's impression shows S & L steel pipes supplied for the North of Scotland Hydro-Electric Board's Tummel Garry scheme.

These pipes are 30¾ inches outside diameter and $\frac{5}{16}$ inches thick. They have sleeve joints for welding, with a Vulcan expansion joint between each pair of anchors.

The pipeline is to convey compensation water from Errochty Dam, which can be seen in the illustration, to a power station near Trinafour.

Consulting Engineers: Sir Alexander Gibb & Partners

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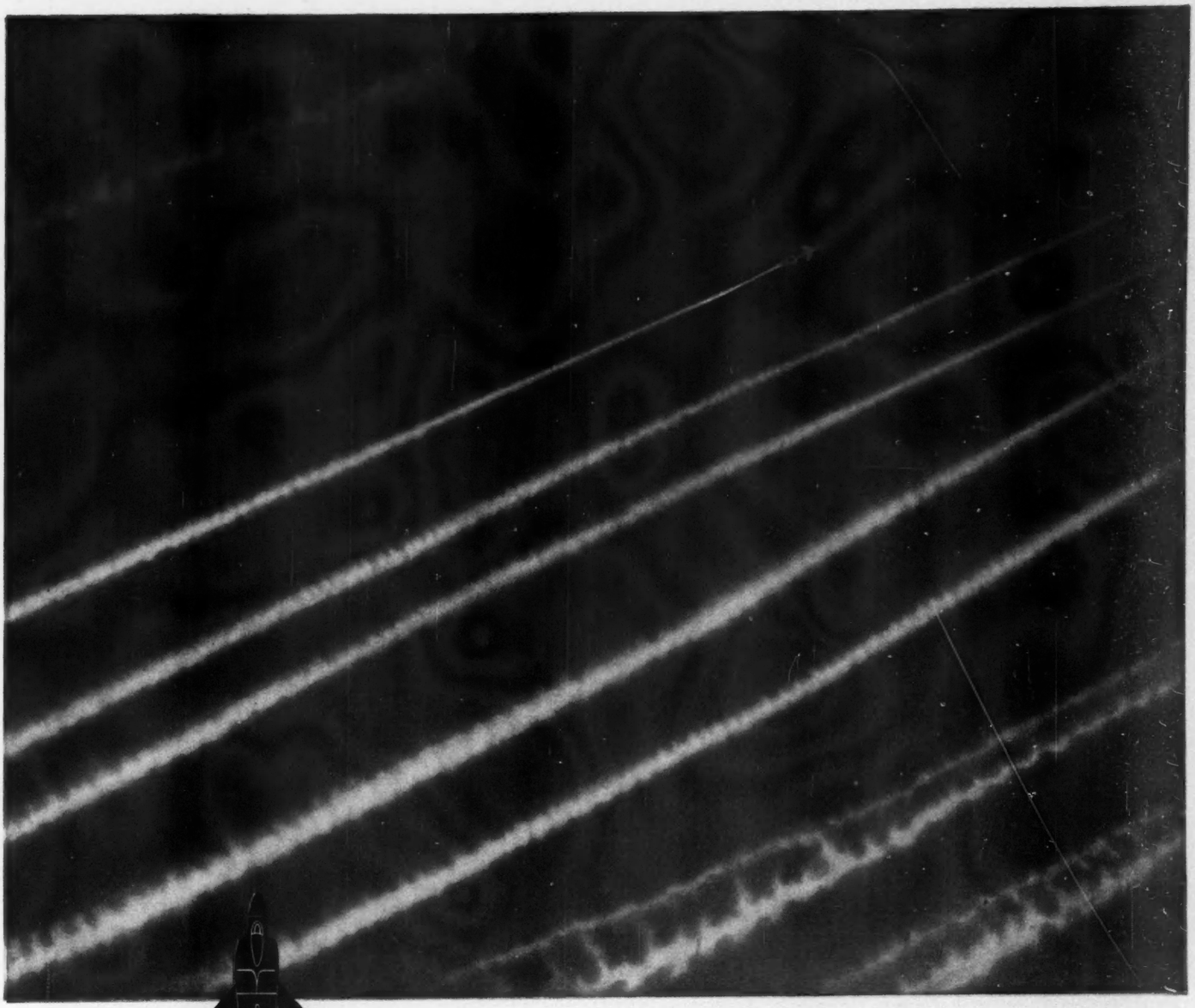

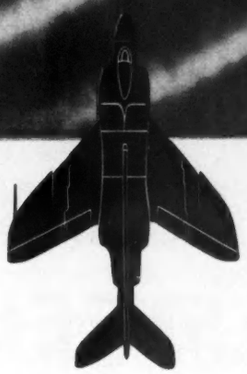

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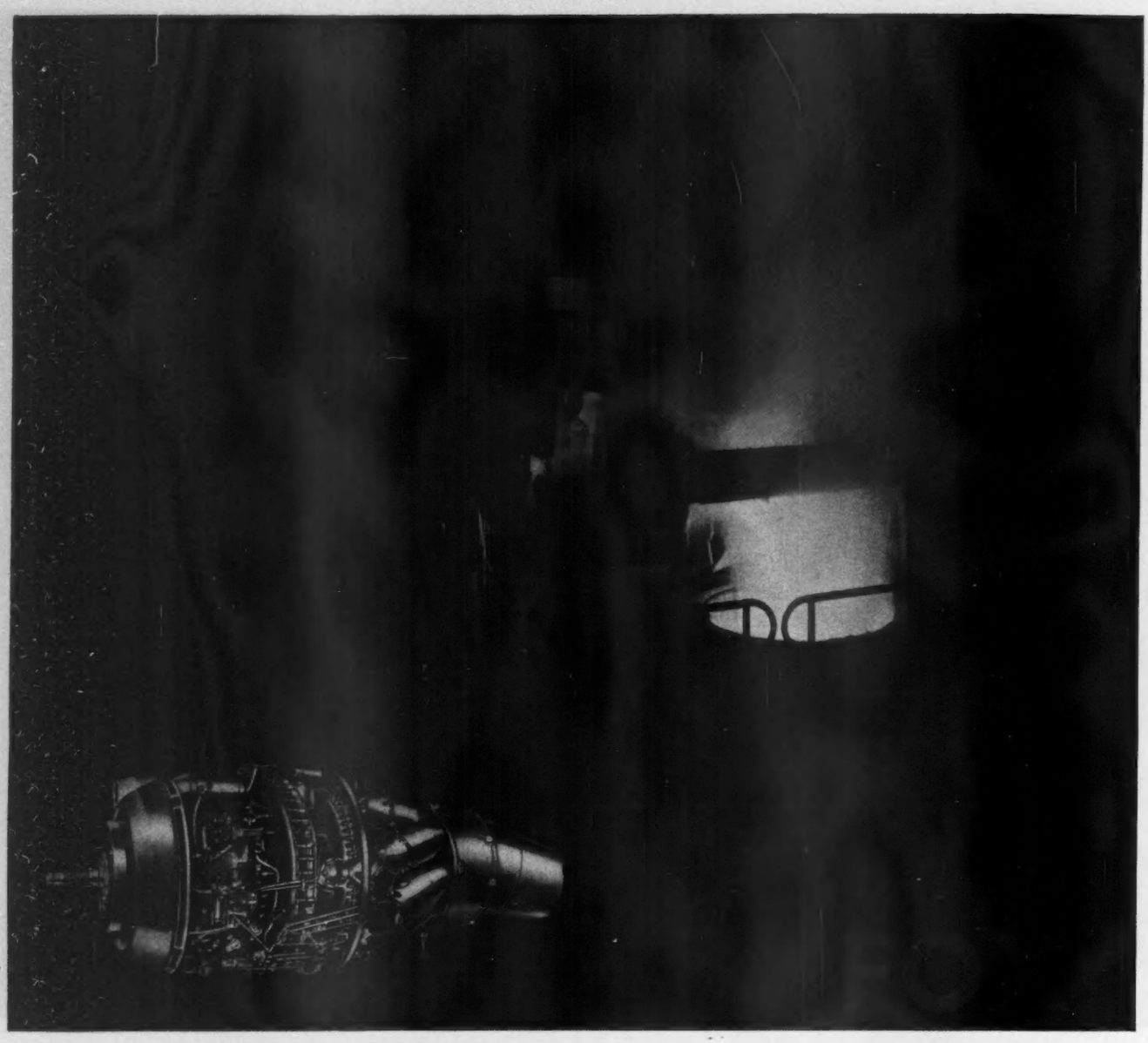

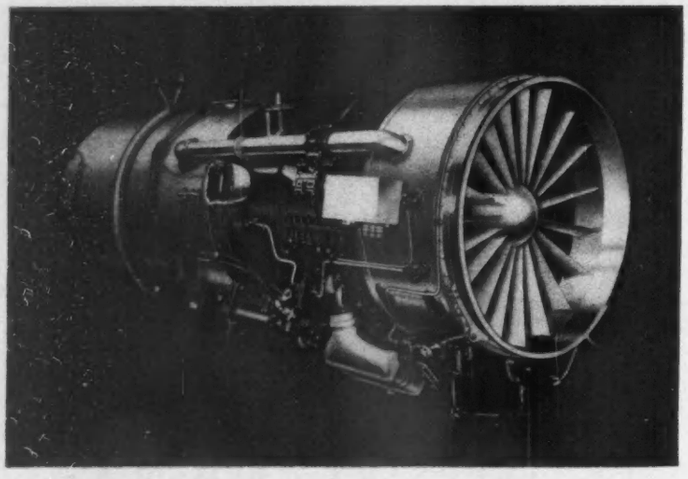

ALLOY STEELS

The Rolls-Royce Conway (left) and the Rolls Royce Dart (above, left) gas turbine aero engines make use of the unique properties of Fox Fortiweld and Jethete steels.

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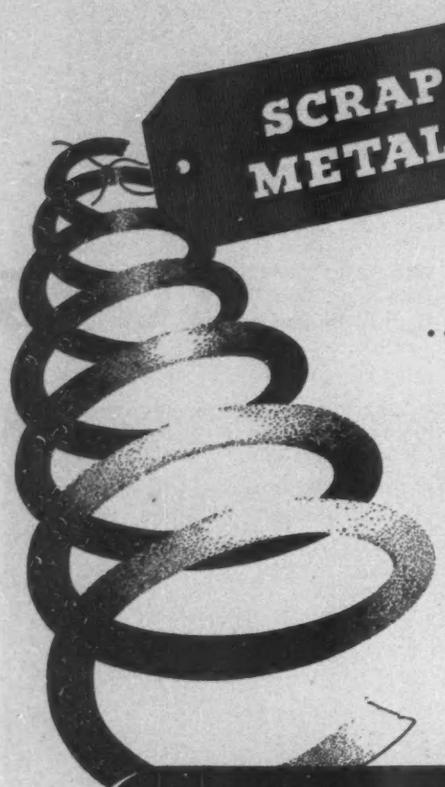

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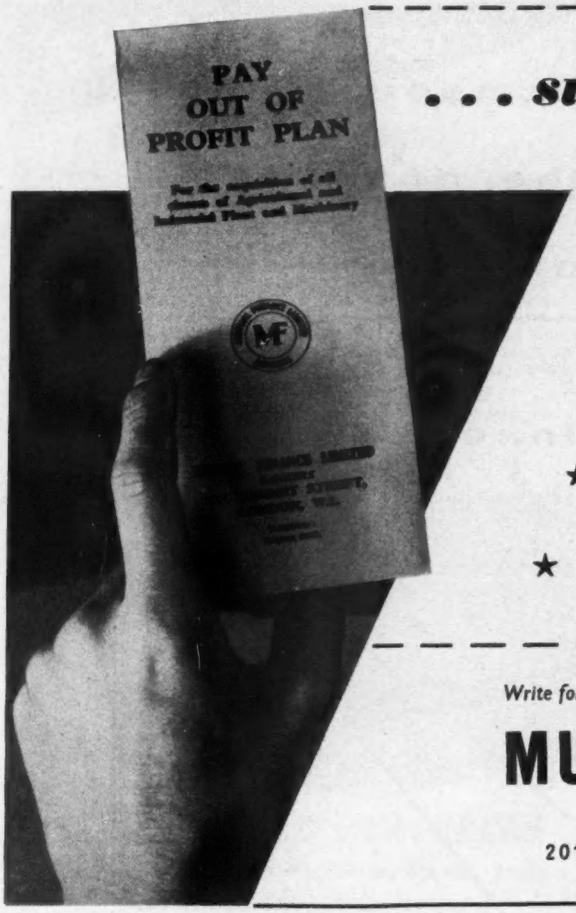

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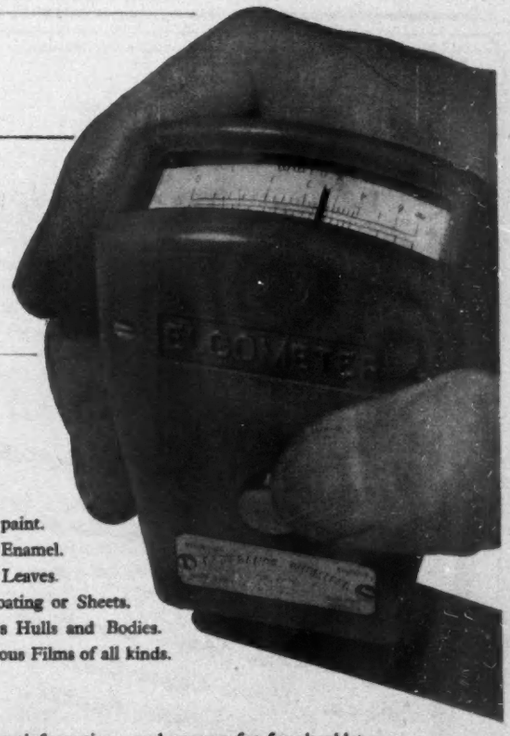

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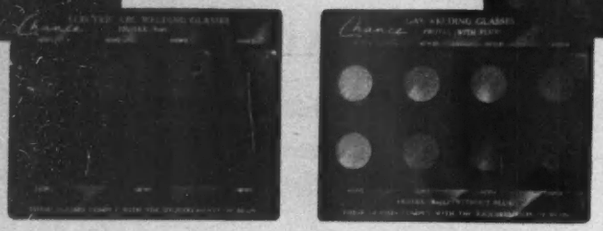

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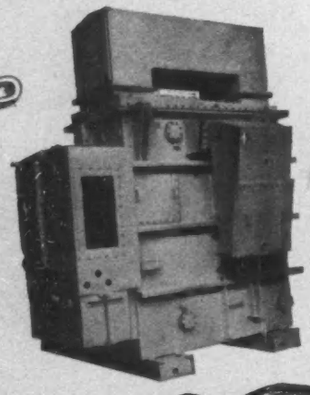

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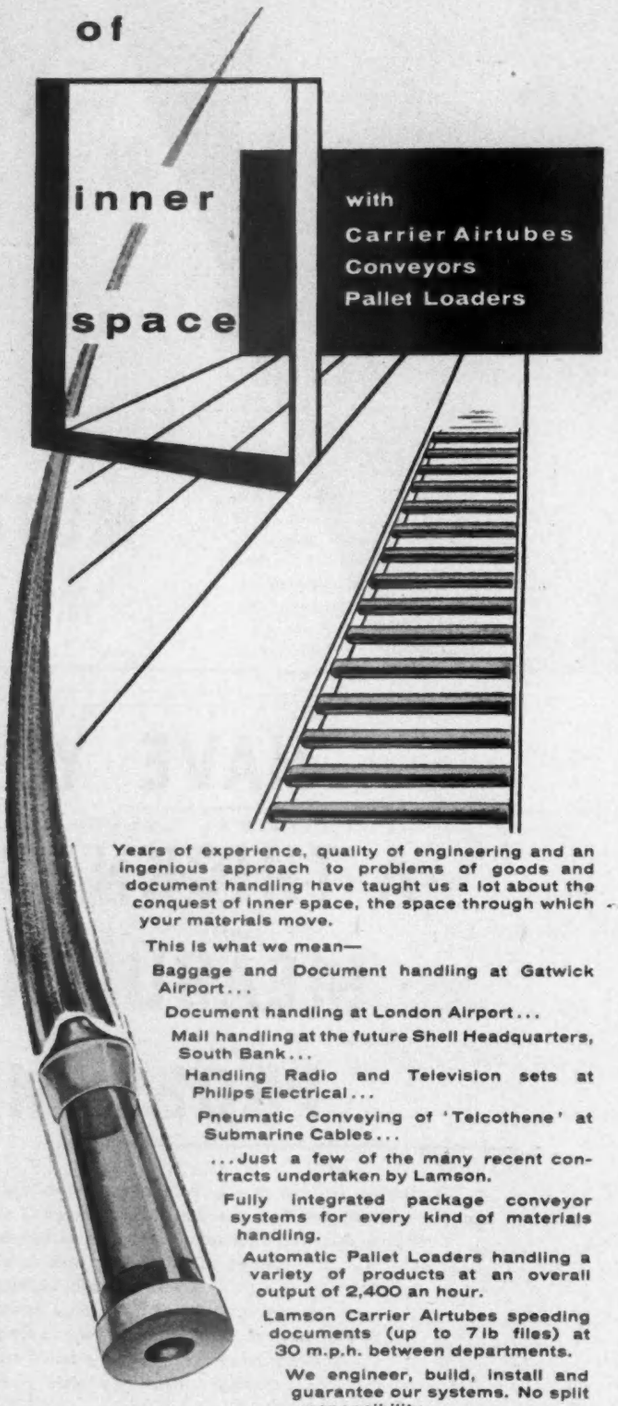

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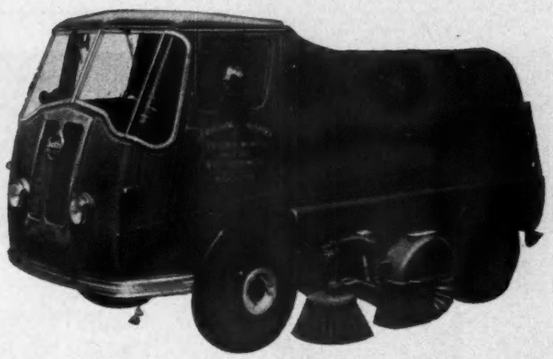

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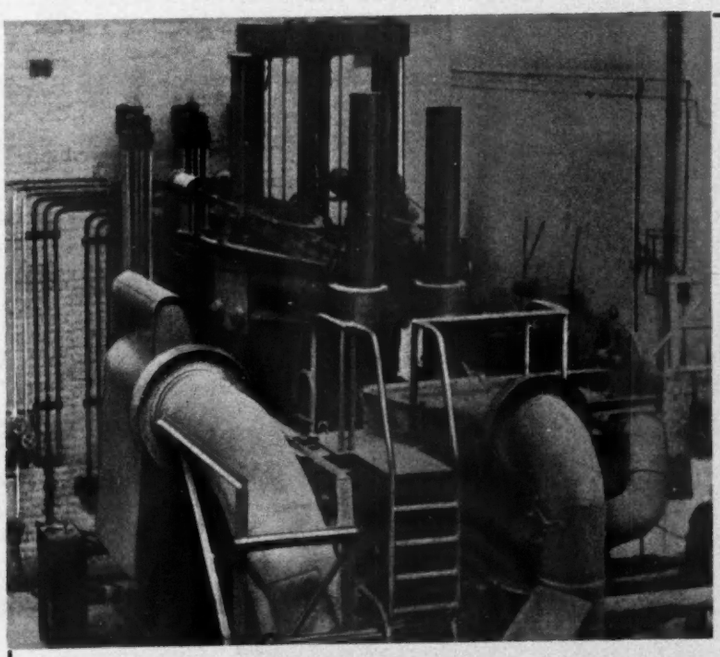

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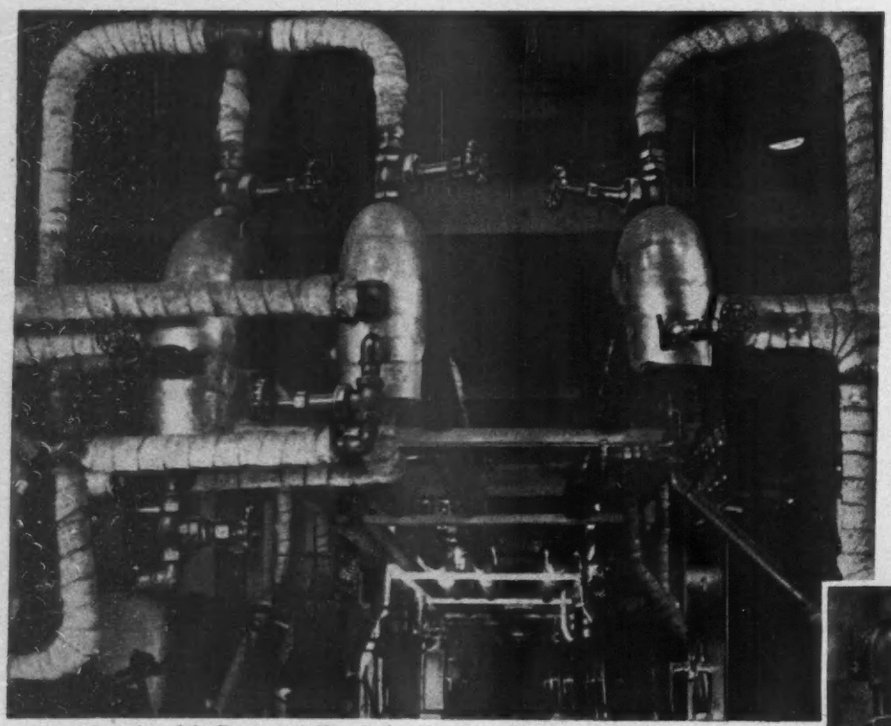

A section of the Bag-o-matic Tyre Curing plant featuring Crane No. D186 valves.
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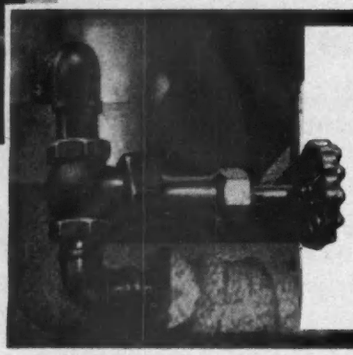

Crane No. D186 Bronze Gate Valve, trimmed with nickel alloy wedge disc and stainless steel seats, is suitable for steam working pressures up to 300 pounds per square inch, 550° F.

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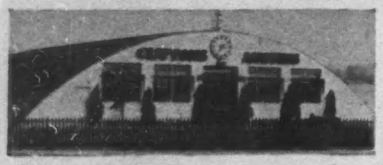

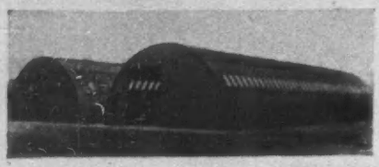

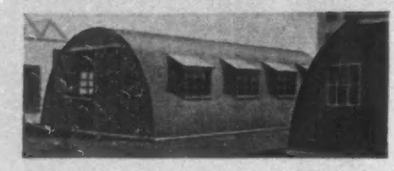

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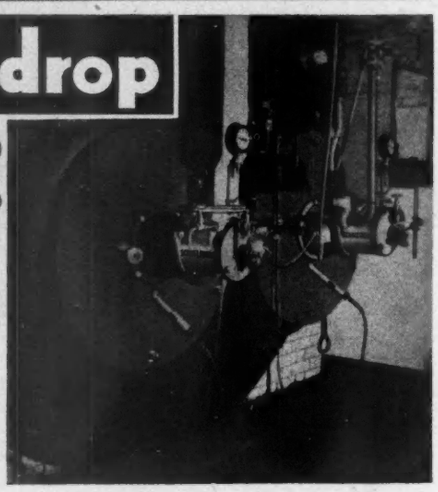

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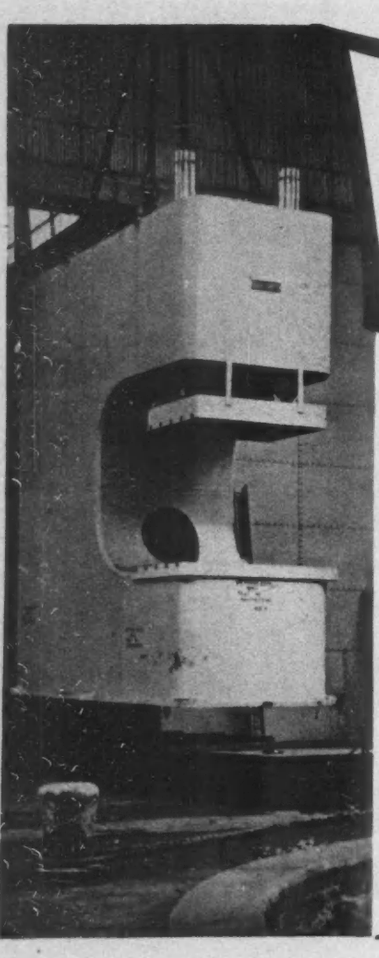

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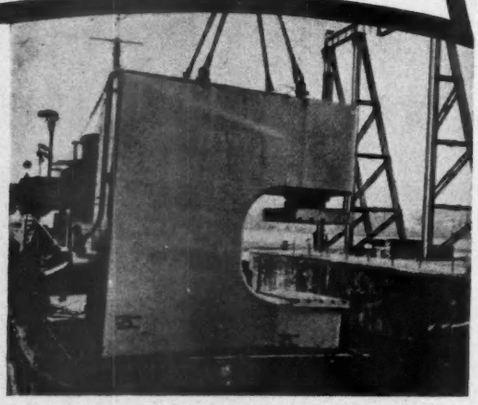

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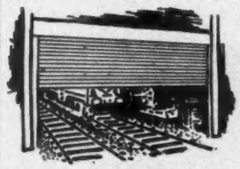

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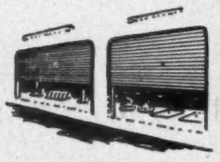

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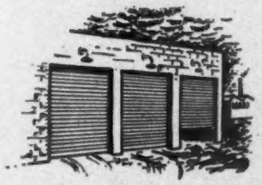

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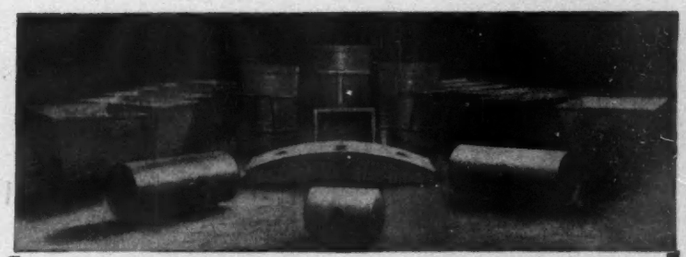

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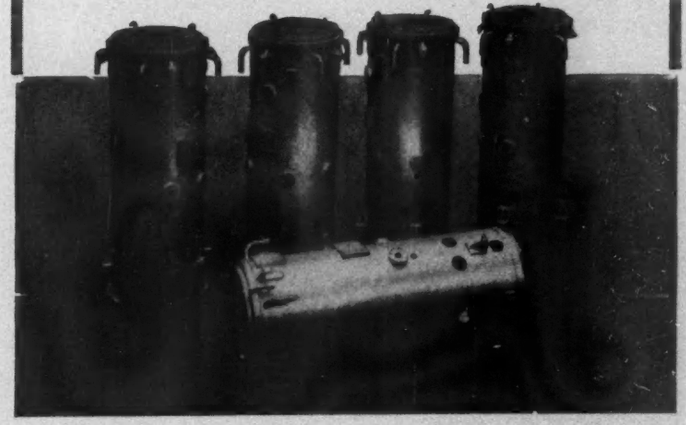

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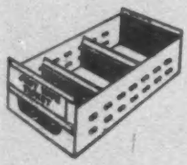

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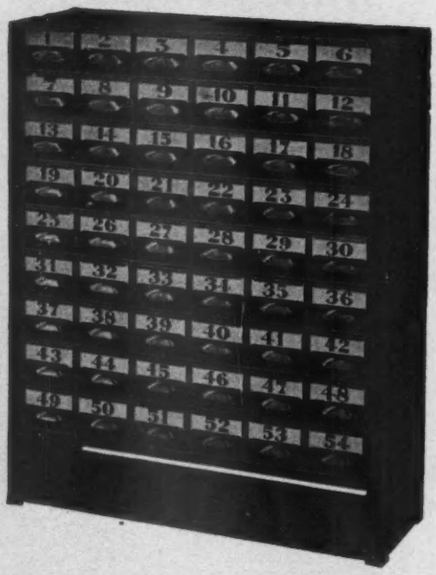

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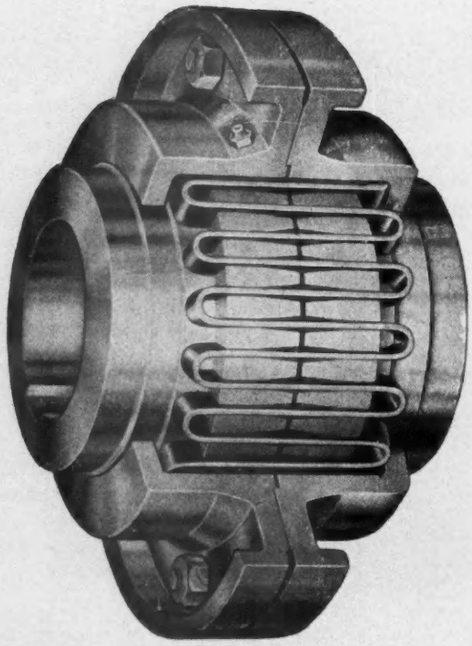

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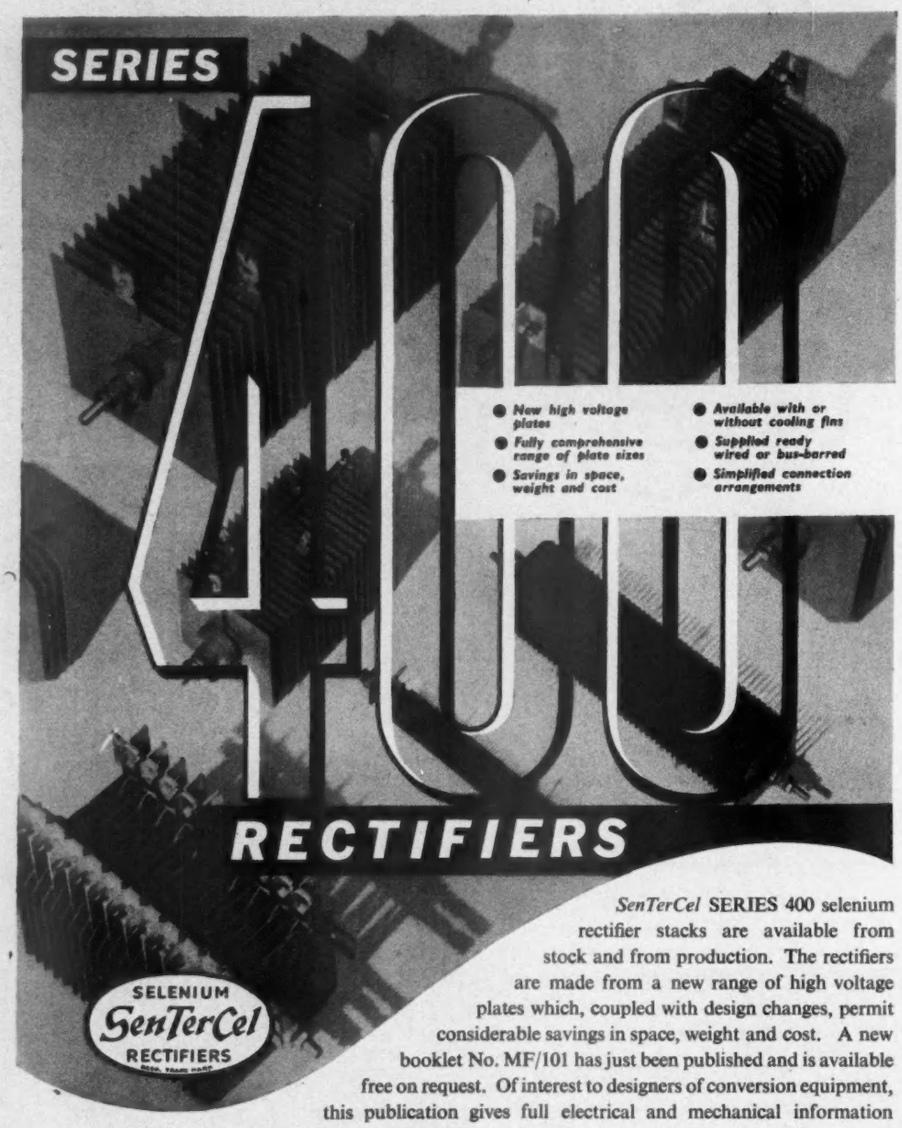

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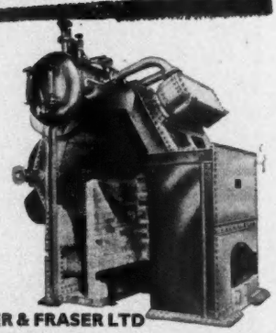

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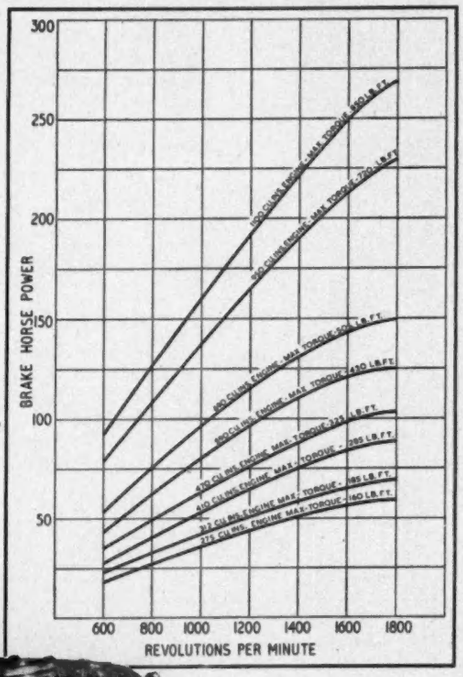

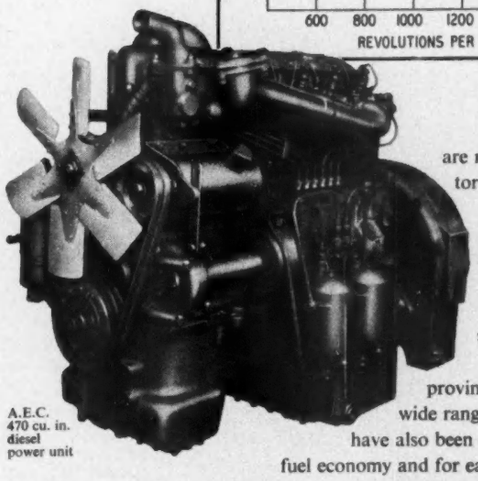

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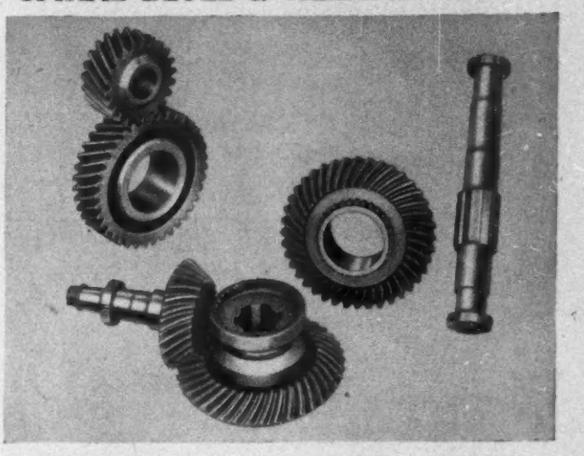

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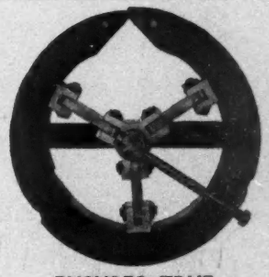

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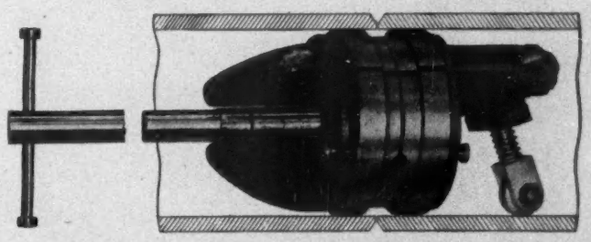

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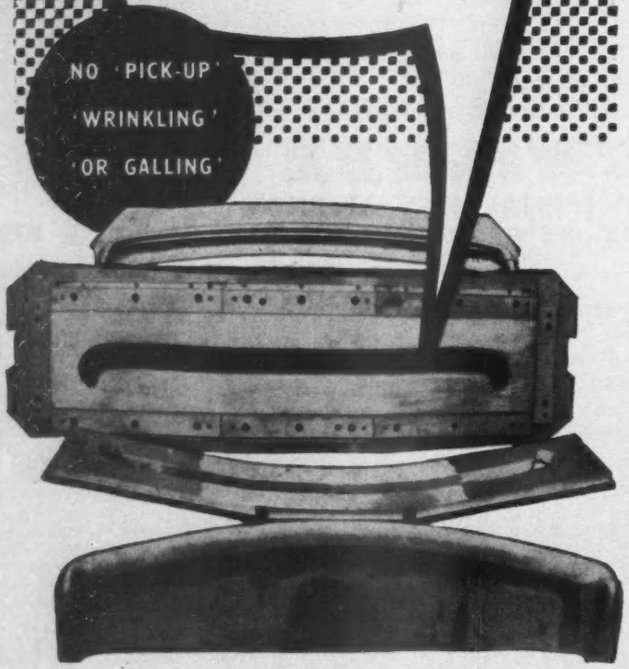

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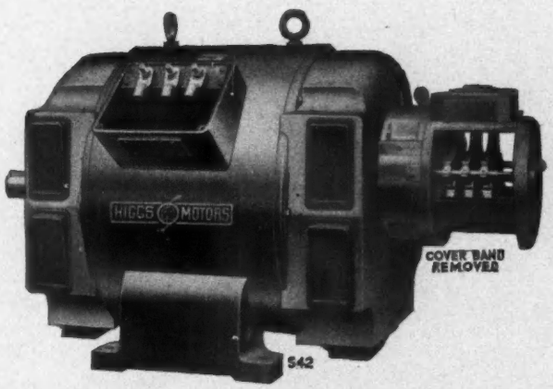

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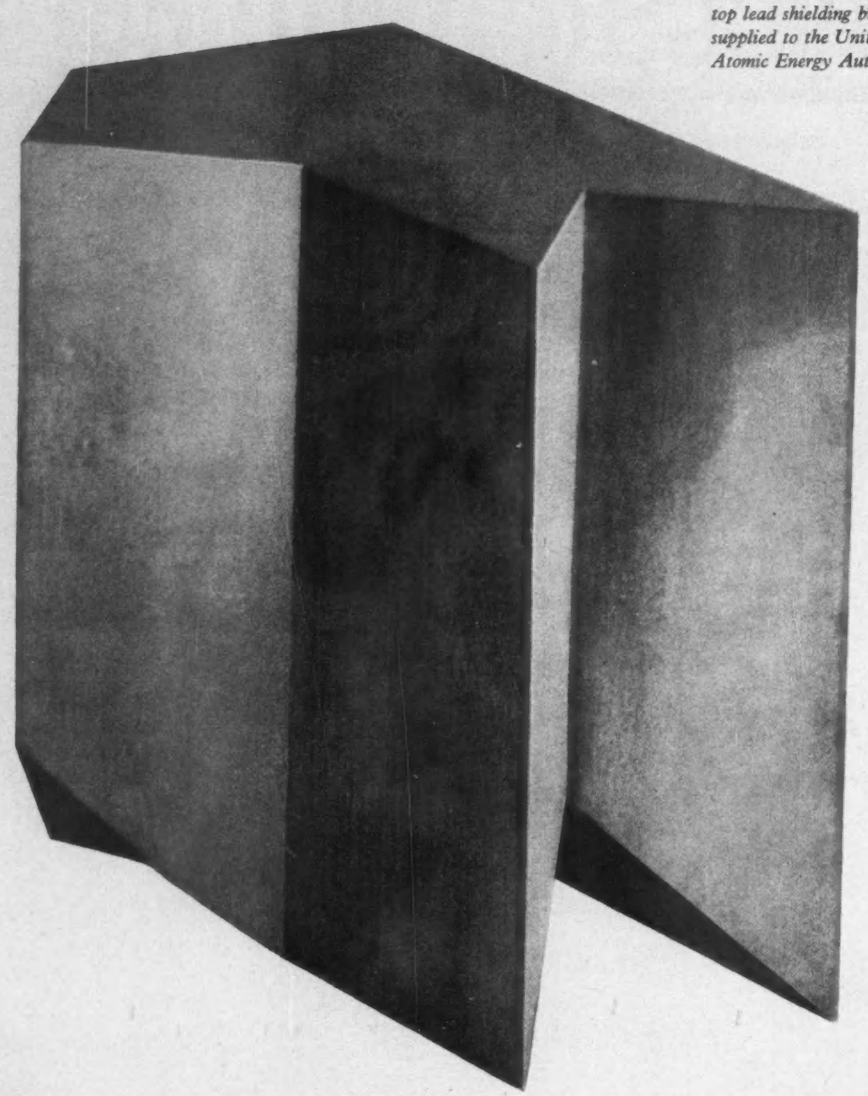

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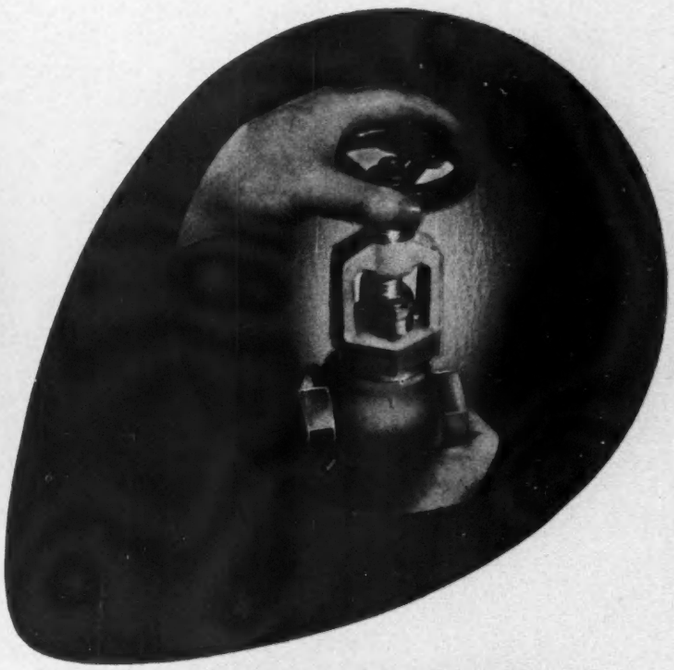

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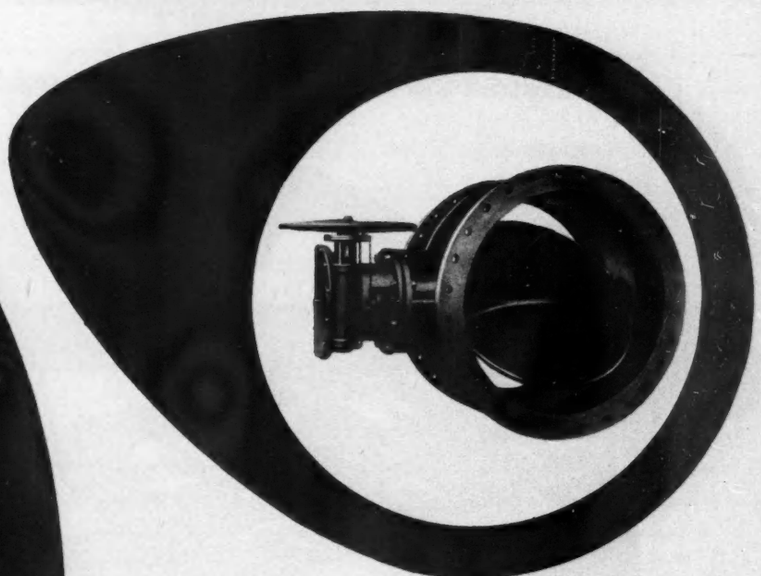
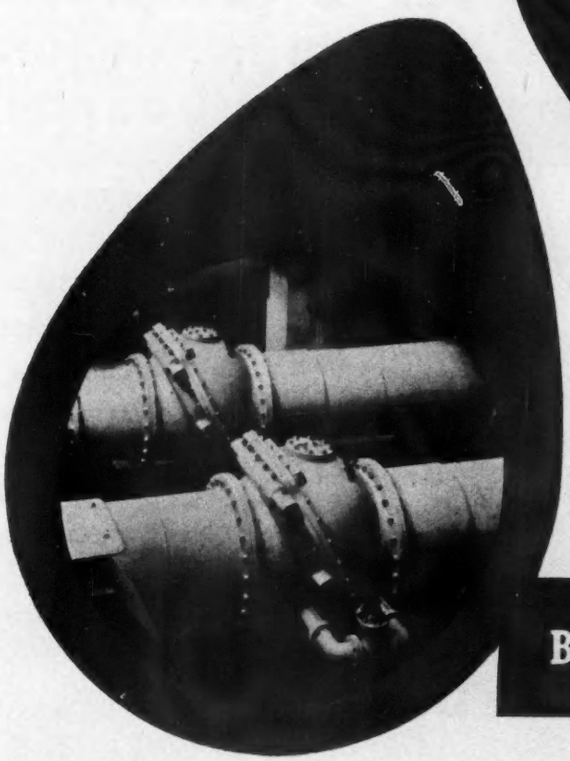
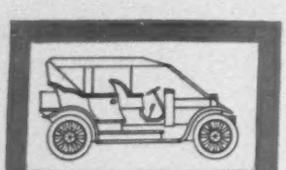




BLAKEBOROUGH

J. BLAKEBOROUGH & SONS LIMITED BRIGHOUSE ENGLAND

E



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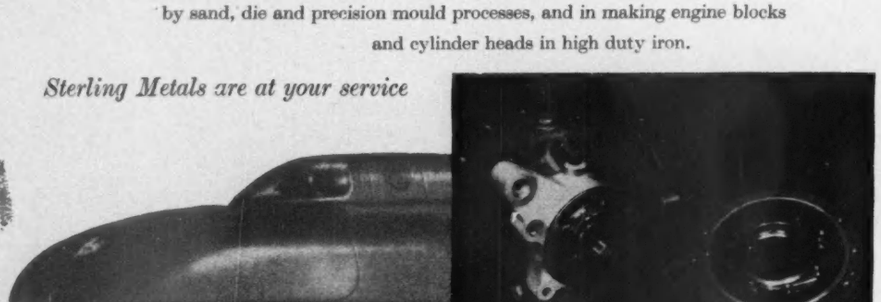

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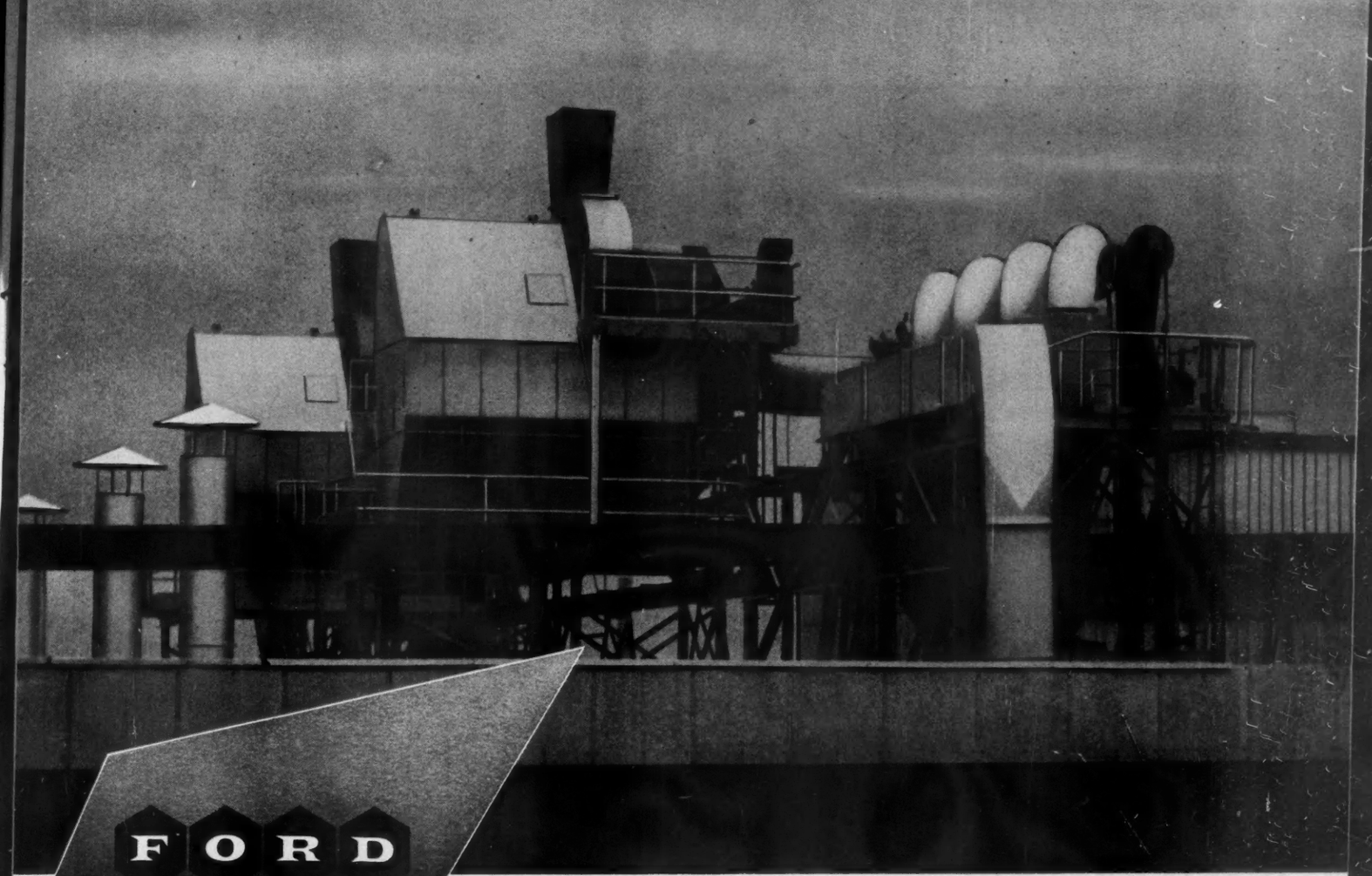

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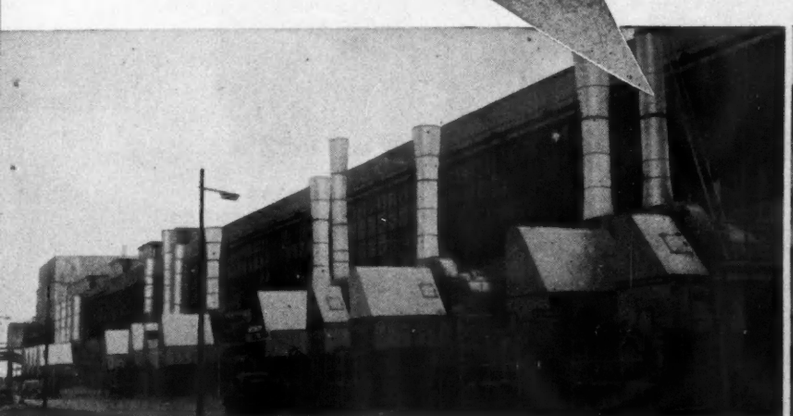

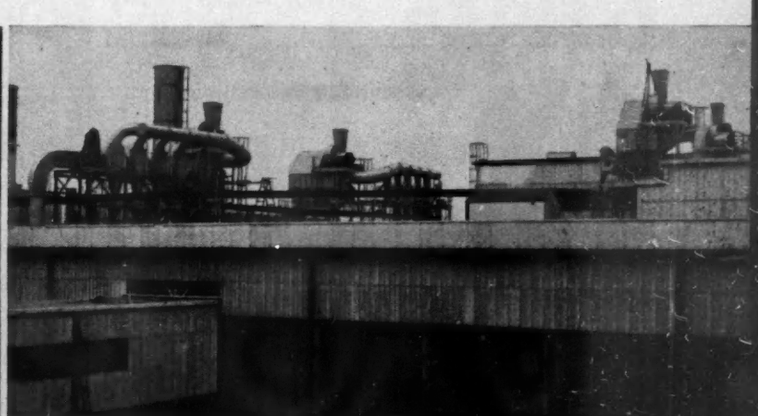

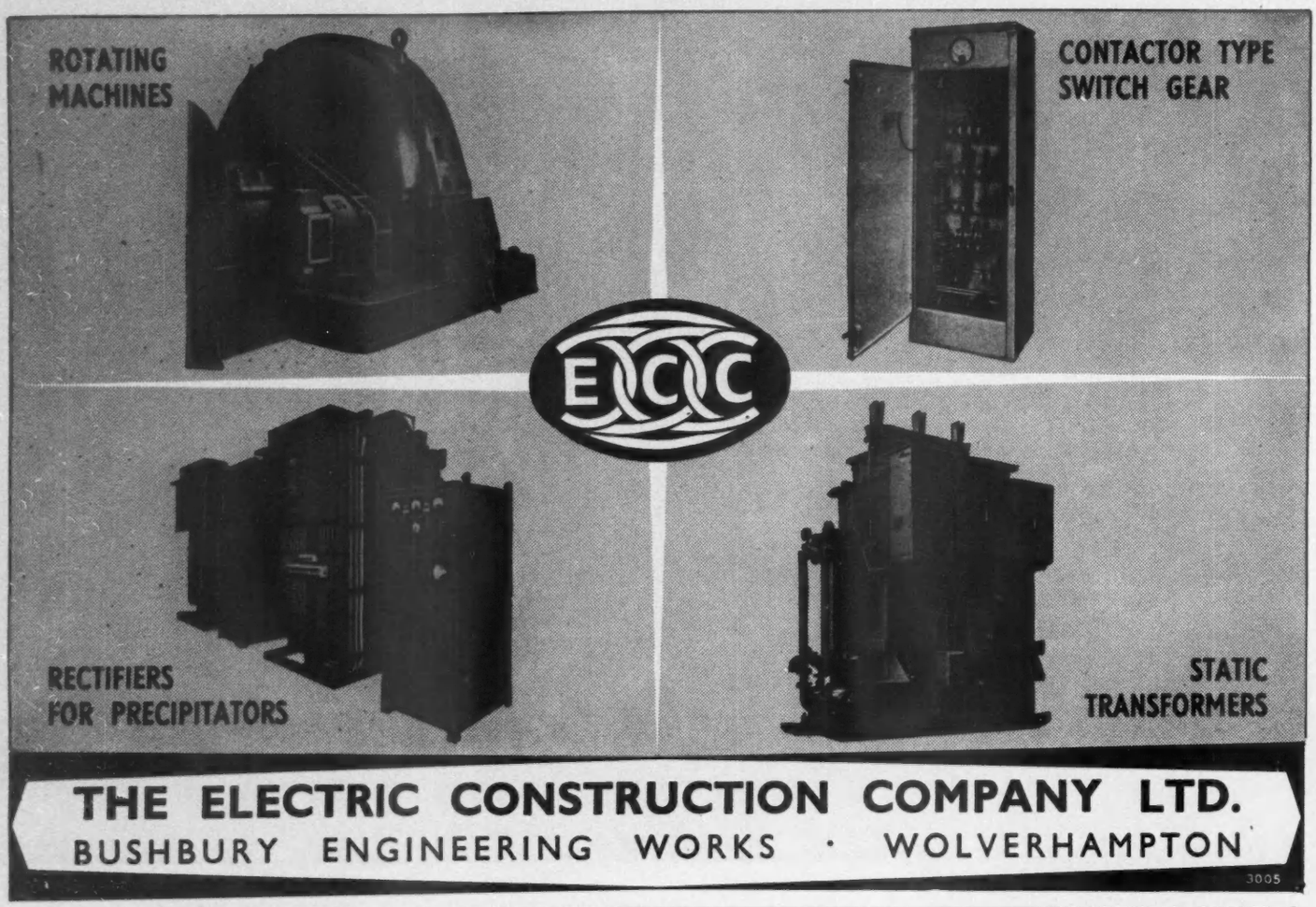

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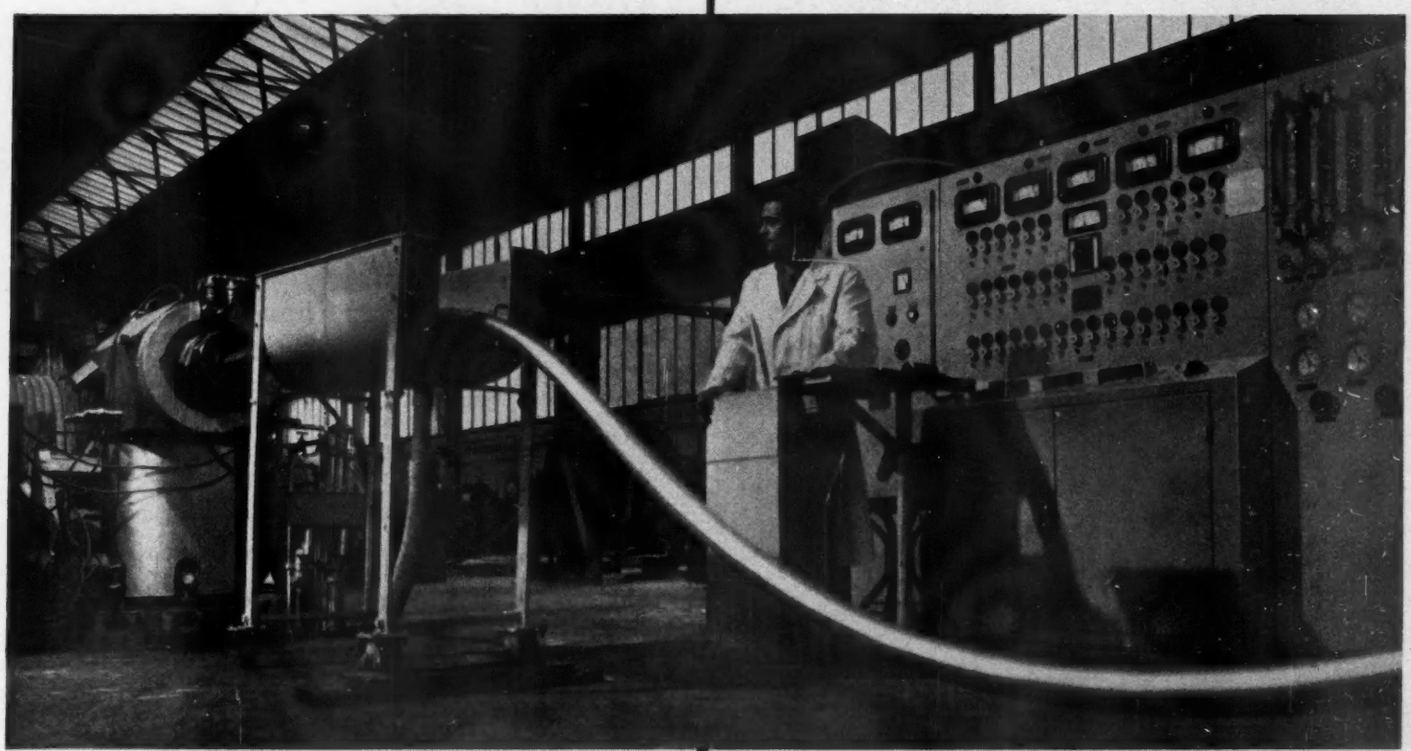

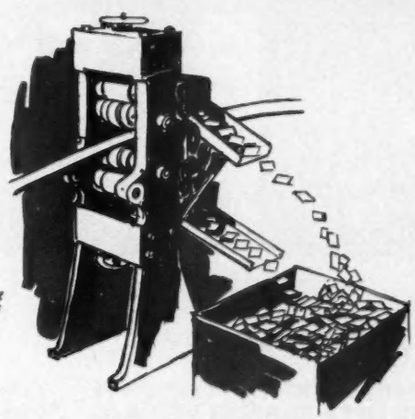

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GOOD FOR YEARS OF SERVICE

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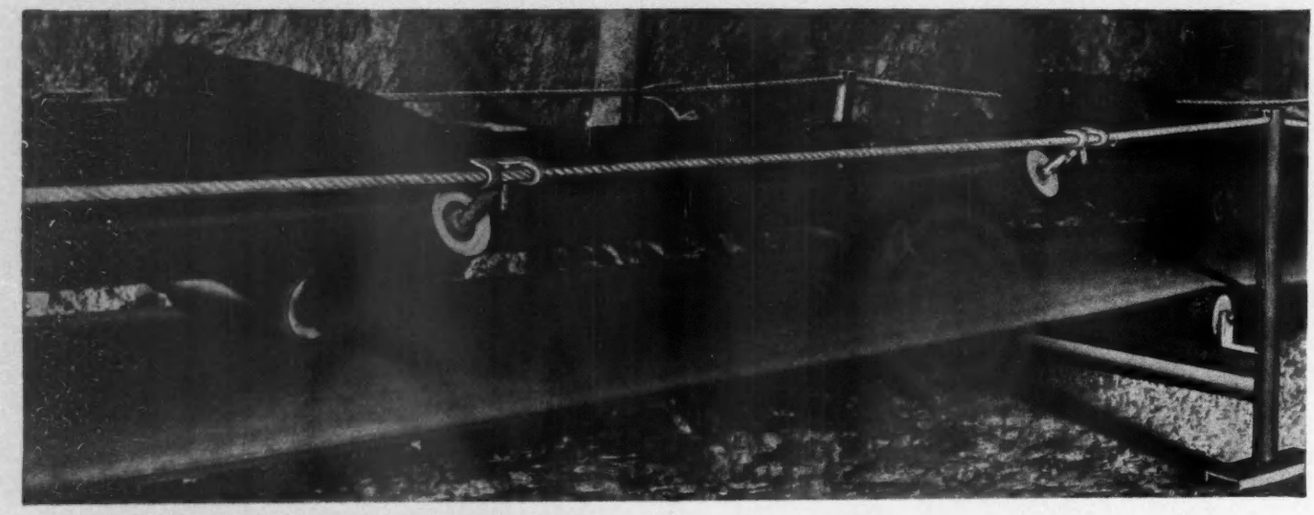
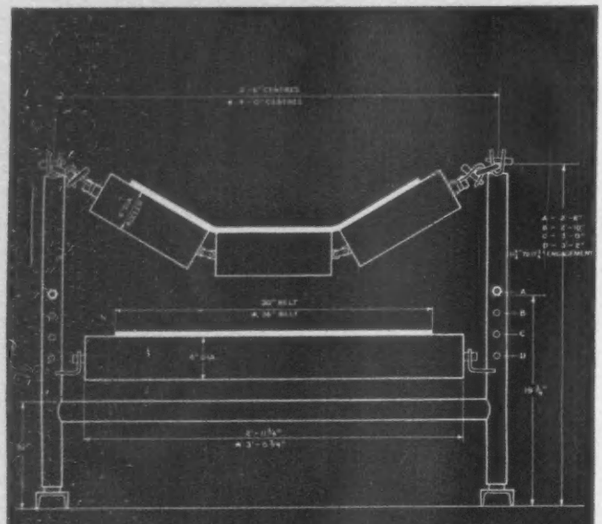
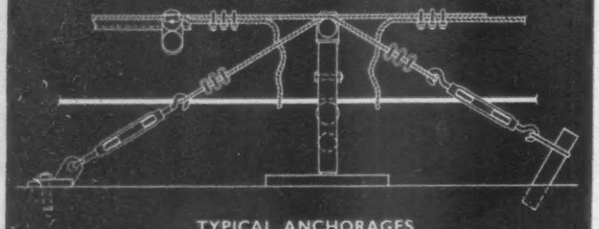




INTERMEDIATE STAND
(Adjustable for height)



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- ***— reduces installation costs***
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- ***— almost eliminates spillage***
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ROPE STRUCTURE

Greater conveying capacity obtainable by increased troughing under load

The longitudinal members of this conveyor structure consist of $\frac{5}{8}$" dia. steel ropes in tension. The connections at the ends of each troughing idler shaft are hinged. These basic features provide a resilient conveyor which is easy to stack, transport and install — a conveyor in which impact damage to the belt as it passes over the idlers is greatly reduced. The belt is easy to train. The bottom belt is in full view and there need not be any concealed rubbing between belt and structure.

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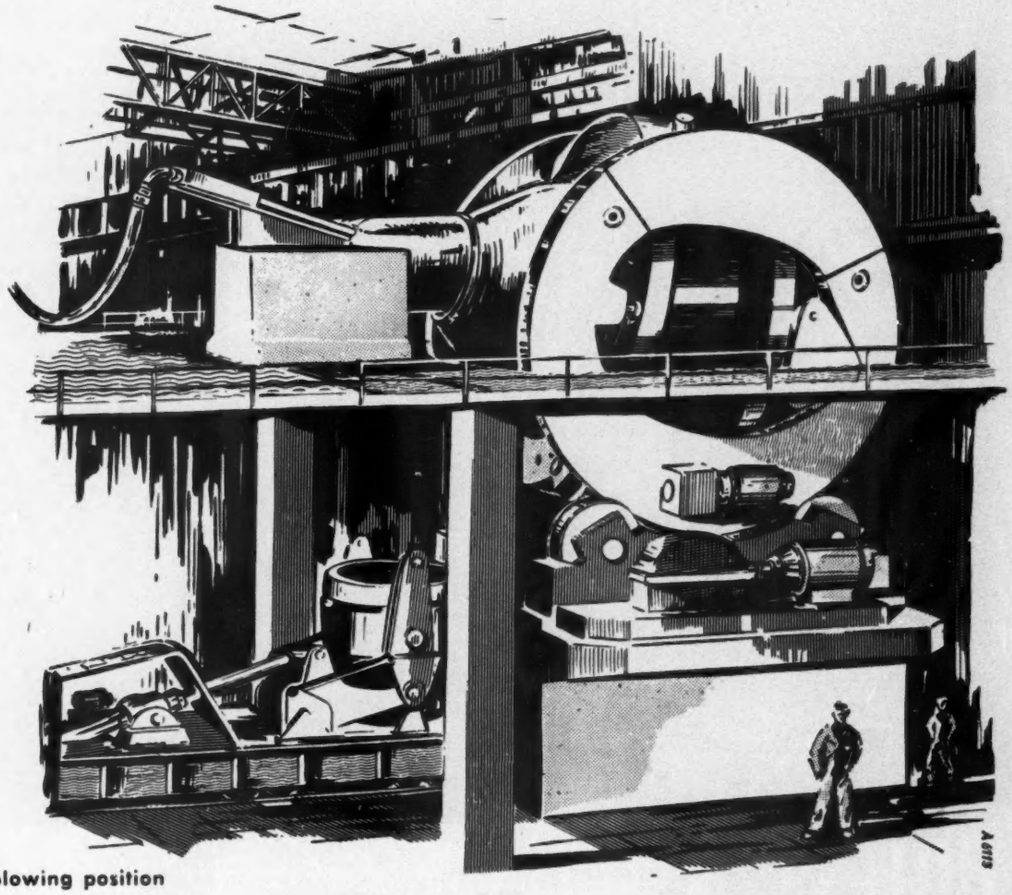
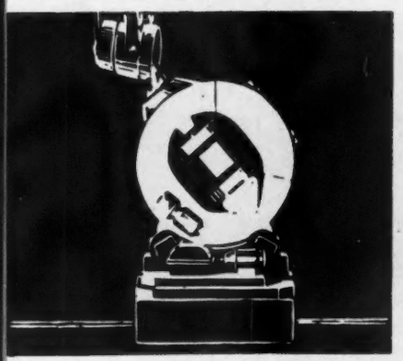
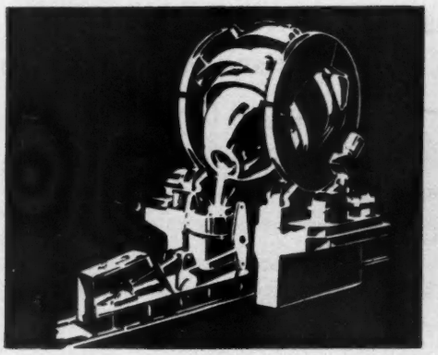


Furnace in the blowing position

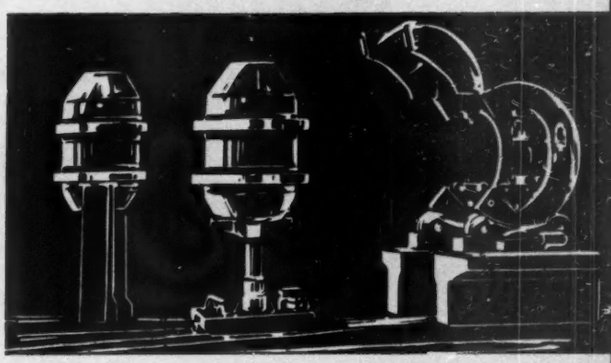
Hot metal being poured into furnace



Steel being poured from the furnace



Exchange of the vessel



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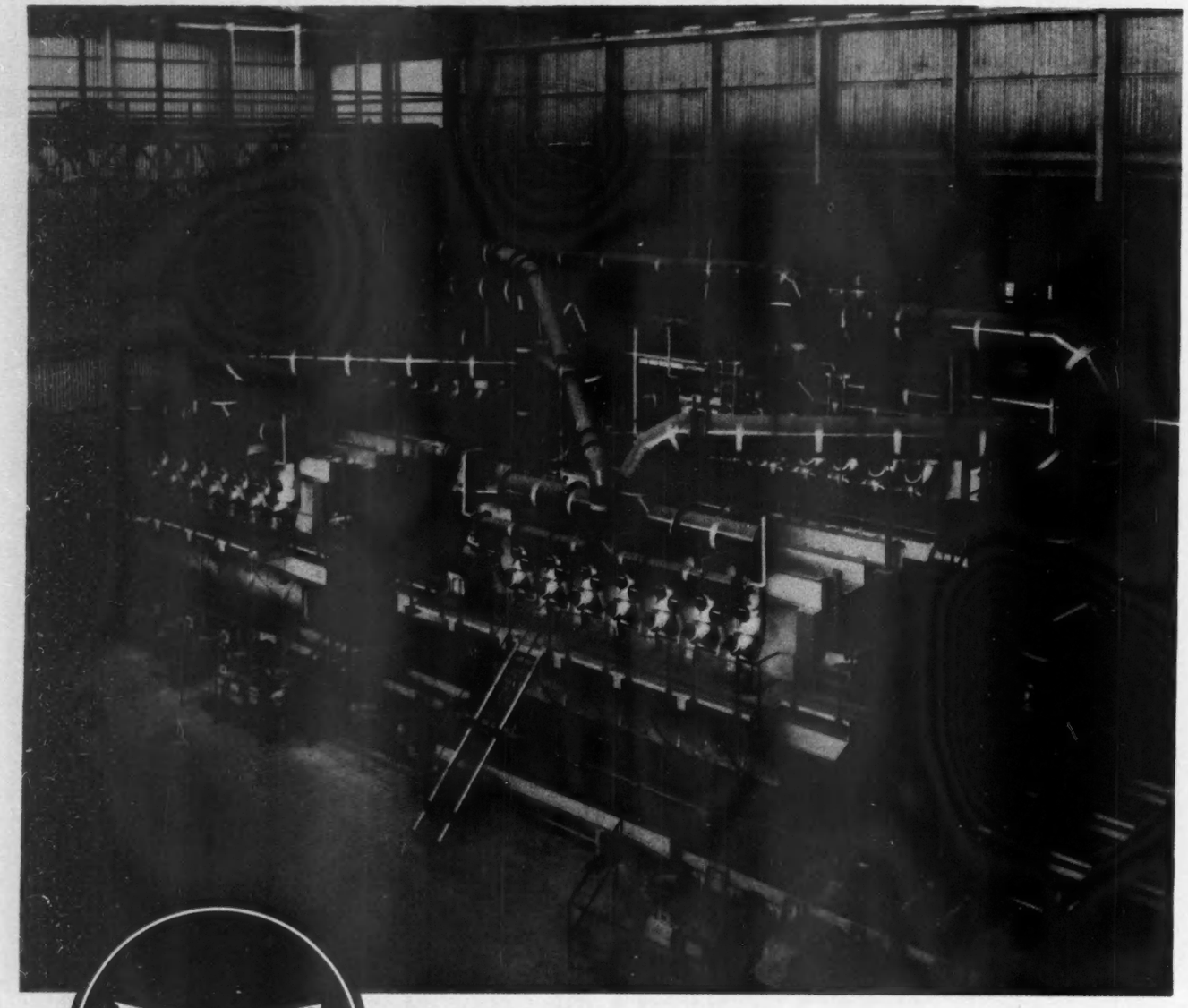

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3 zone Bloom Re-heating Furnaces

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The 'Marvex'	,,	½–4 tons
The 'Mammoth'	,,	2½–13½ tons

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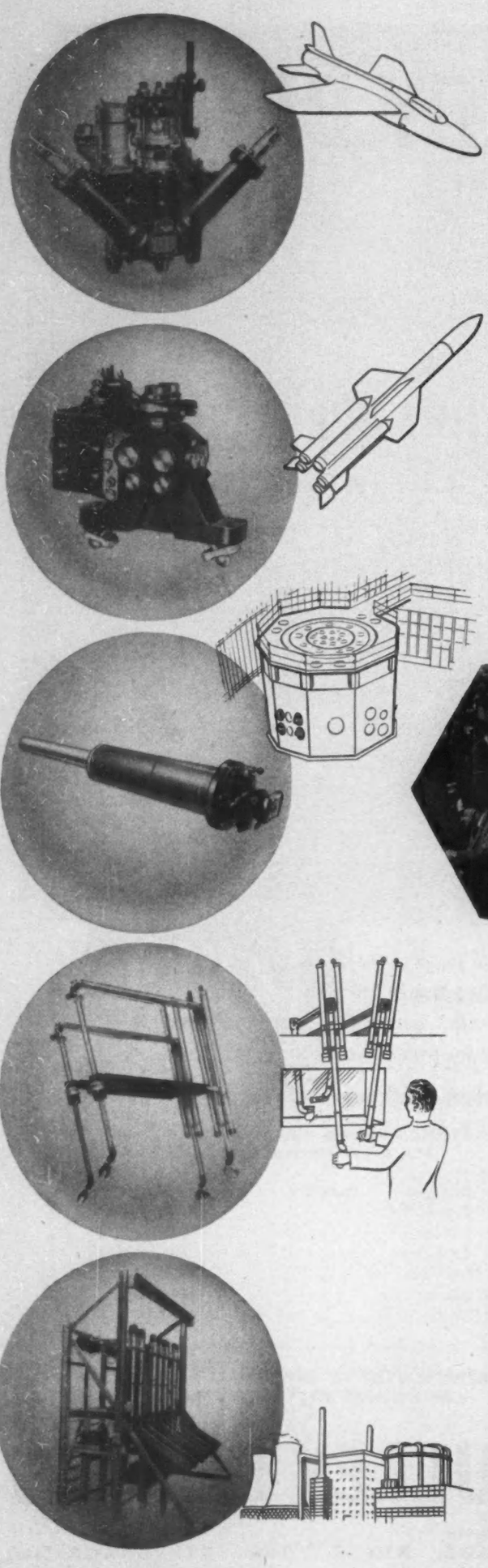

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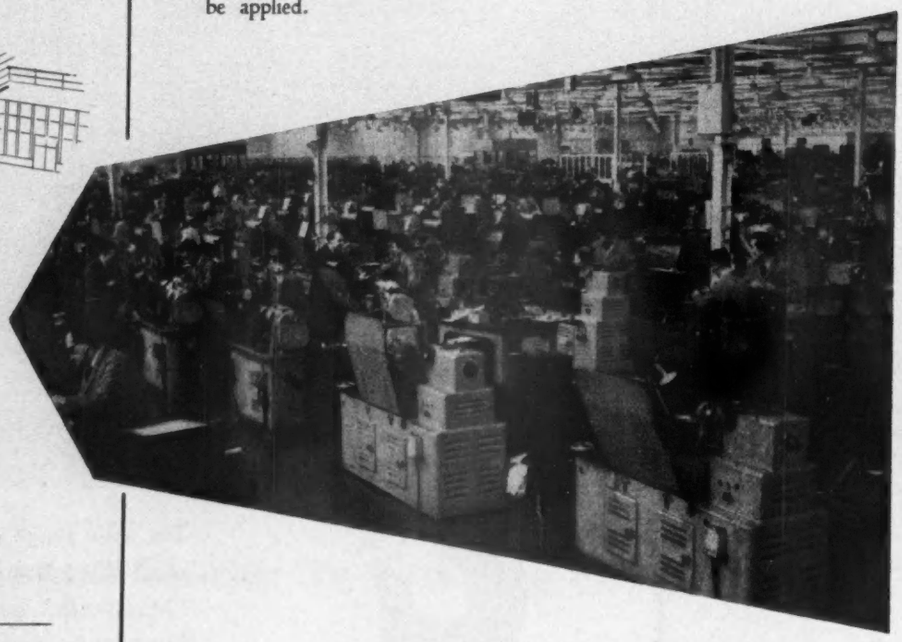

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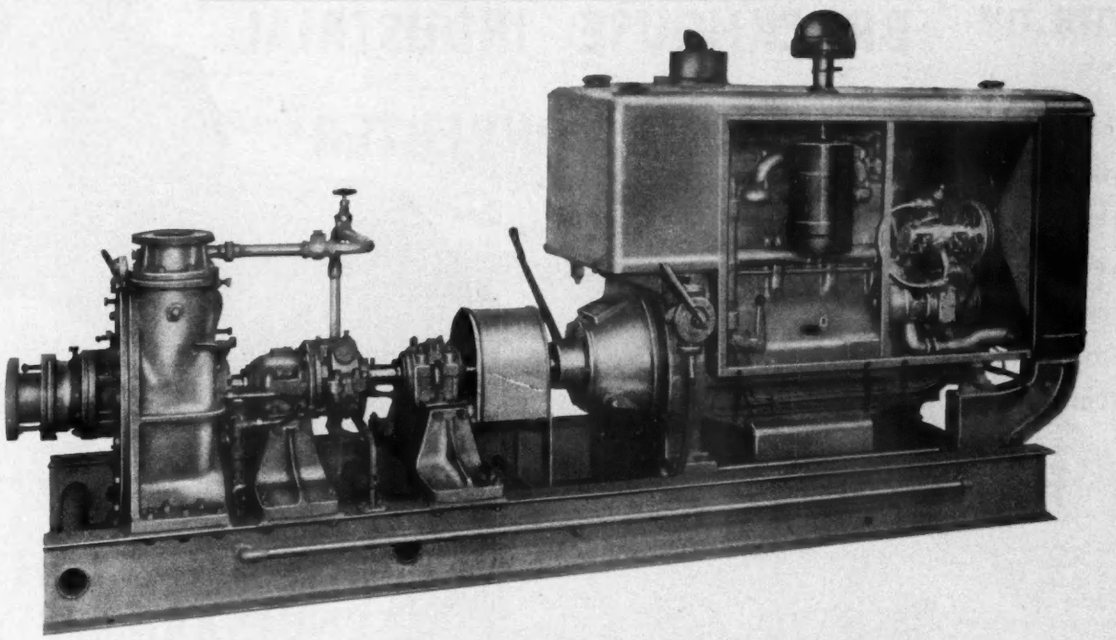
GRAVEL PUMPS



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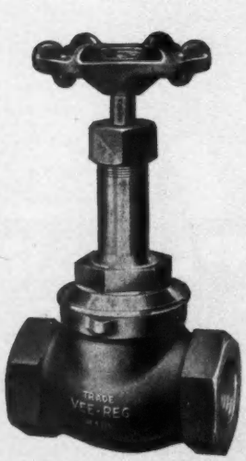

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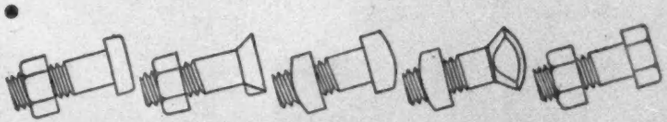

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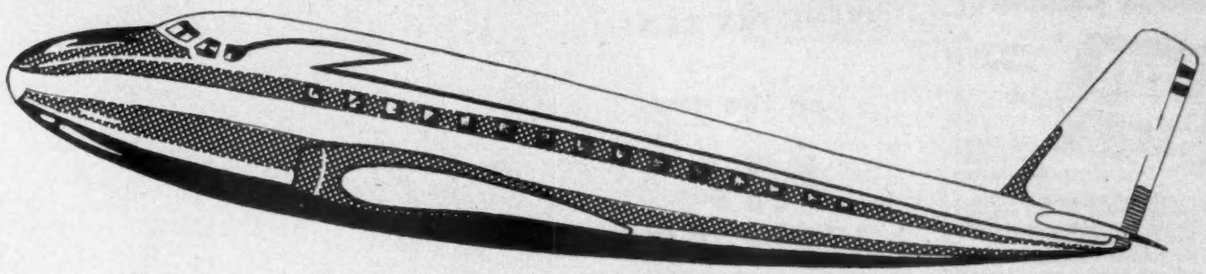

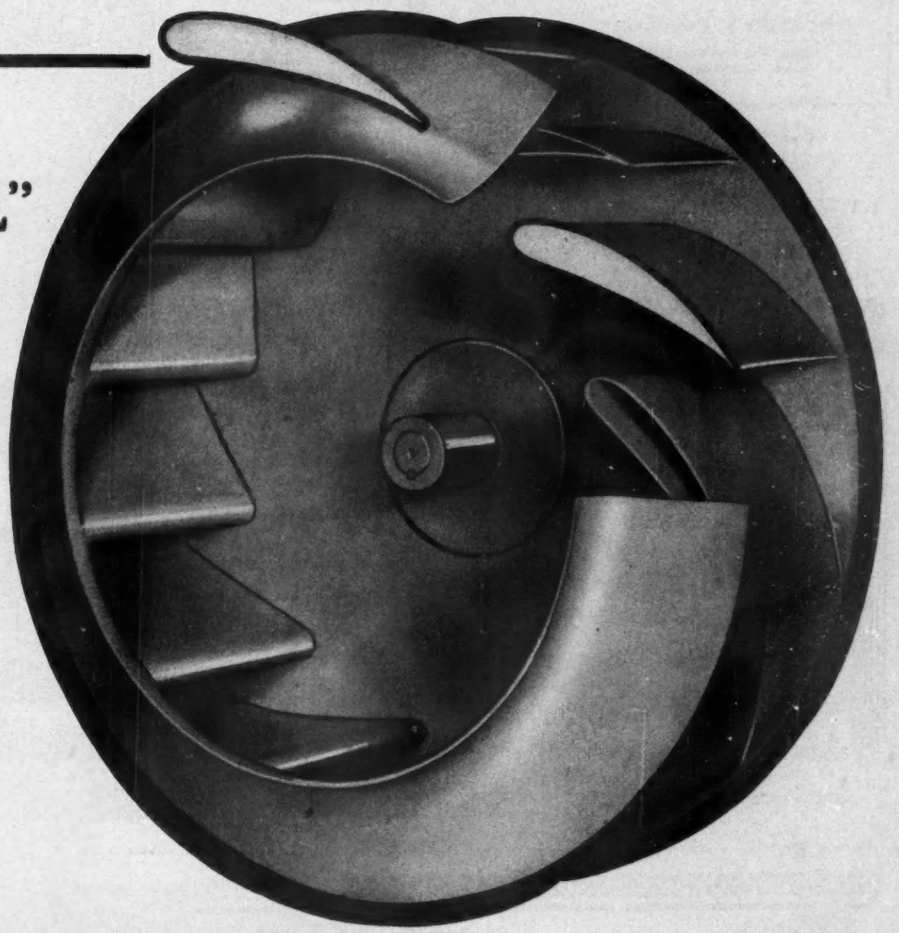

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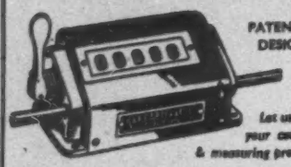

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- **REMOVES BROKEN TOOLS WITHOUT DAMAGE TO THE COMPONENT**
- **CUTS HOLES OF ANY SHAPE IN HARDENED MATERIAL, CARBIDES ETC.**

. . . in fact any material through which electric current can pass.

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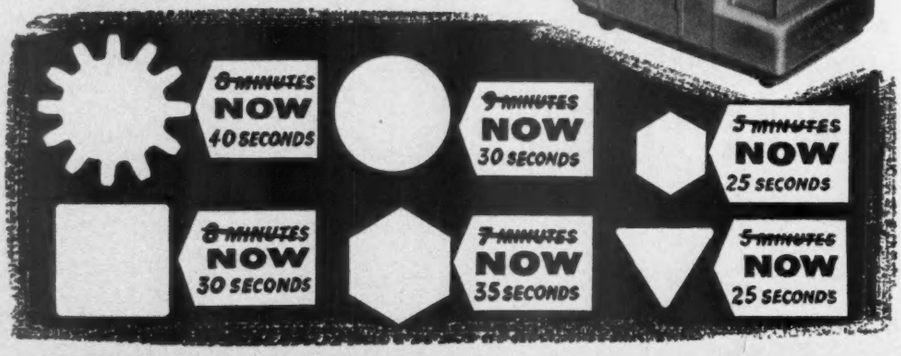
Times obtained on Model M58-C (as illustrated)


8 MINUTES NOW 40 SECONDS
9 MINUTES NOW 30 SECONDS
5 MINUTES NOW 25 SECONDS
8 MINUTES NOW 30 SECONDS
7 MINUTES NOW 35 SECONDS
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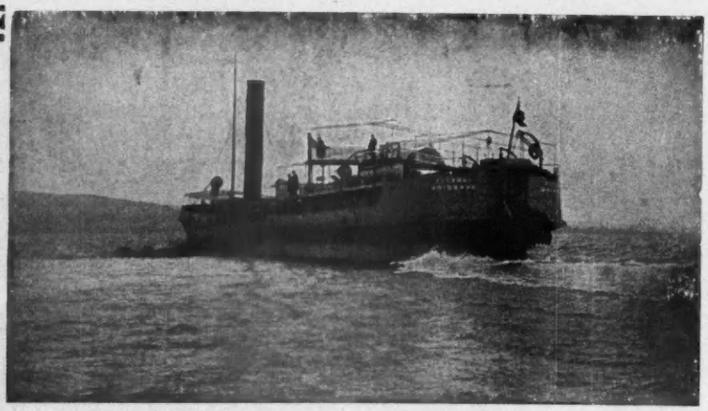

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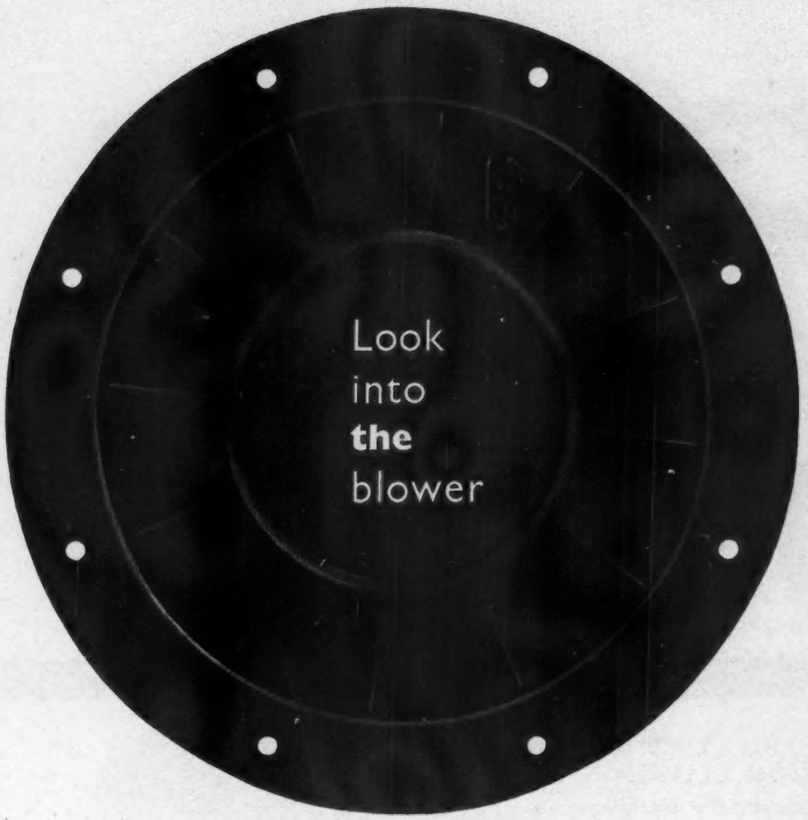

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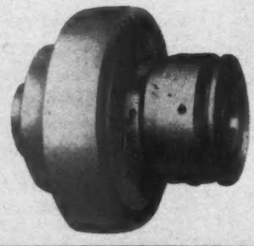

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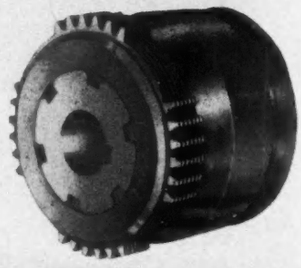

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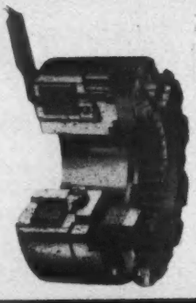

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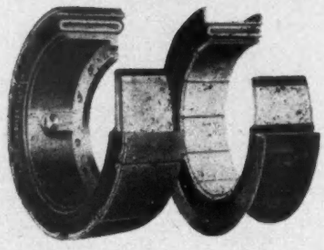

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THE ENGINEER

No. 5347 JULY 18, 1958 VOL. 206

PRESTRESSED BRIDGE CONSTRUCTION

Perhaps we may be excused for having held the opinion that everything possible had been said—and, indeed, published, too—about prestressed concrete. Some demonstrations of a practical nature which we, and many engineers concerned with bridge construction, were invited to see at the works of Concrete, Ltd., have shown otherwise. Precast prestressed bridges of four selected designs and one *cast-in-situ* post-tensioned design covering the most common requirements of spans and loadings, were selected by this firm for a series of practical erection trials. Alternative methods of carrying out certain specific parts of the erection—such as cross stressing and using the different proprietary systems of post-tensioning—were included in the erection schedules, and the whole operation involves method study, work study, and costing of all the various steps in erecting these bridges and prestressing them. Some further details of the bridges erected in these trials are given on page 92.

The reasons why such an elaborate research is being carried out are interesting. It offers facilities for training the erection crews, but this seems to be a rather subsidiary reason. Further, the firm is not yet committed to production designs of bridge beams, and obviously, at this stage, a certain amount of research and investigation would be expected before the production designs were finalised. But the scope of the work goes beyond what would be expected on that account, and, indeed, as far as we are aware, work study of this kind, and of this thoroughness, is quite new in its application to precast concrete structures, and somewhat rare and unusual in civil engineering generally. The impression is gained that exponents of the various systems of prestressing may not have been too frank about the difficulties experienced on the erection site ; hence, costs tend to rise above estimates. In an appraisal of the economics of bridge deck construction, written as an accompaniment to the trials, Mr. K. M. Wood, of Concrete, Ltd., expresses this very frankly. Apparent failings in precast prestressed bridgework are, he considers, mainly due to three reasons, namely (1) use of designs which necessitate unnecessarily intricate and expensive on-site operations ; (2) the use of designs involving operations which are too difficult to be completed soundly by normal site operatives ; (3) lack of experience by contractors. This last, he states, can lead to very steep cost increases ; the time required for handling prestressing wire and equipment can be reduced by over two-thirds if the men are properly trained and experienced.

Thus we see that the trials aim at acquiring more precise knowledge of the cost and efficacy of typical site processes. Comparatively simple and inexpensive operations can then be separated from those which prove excessively difficult or expensive, and in the latter case the design or the process modified. Cost data are gained by breaking down and analysing these operations, and this work, too, can influence design, which can then aim more surely at economical production and straightforward erection as well as structural efficiency. Points of practical detail are also investigated ; for instance, the tolerances needed for cross stressing holes in precast elements, and certain practical difficulties in grouting post-tensioned cables. The work is also to include tests on a bridge—built to one-third full scale—comprising hollow box beams placed side by side, and cross-stressed together ; the aim is to verify the conditions under which such an assembly may be treated as a slab bridge in design, rather than as a series of separate beams. All this work is at the heart of the problem of producing a cheap and efficient structure. It is especially important at the present time, when a great expansion in road building is expected, particularly in the construction of motorways, with their many bridges, and of urban routes such as the West London motorway, which is to be built partly as a viaduct. From the national point of view, it is probably unimportant which structural material predominates in the construction of bridges such as these, but it is important that the designs used should reach towards finality in economy.

EDUCATION OF CIVIL ENGINEERS

Next September a rather unusual conference on education is to be held at the Queen's University, Belfast. Usually when the education of engineers is discussed no distinction is drawn between education for civil, mechanical, electrical, chemical, &c., engineers unless the discussion becomes so detailed as to study a syllabus. But the organisers in Belfast believe that there are particular facets of an education for civil engineering which cannot adequately be covered by a general discussion of engineering education. They point out, for example, that civil engineering differs from other branches of engineering in the way it is organised. First, each product is an individual design so that repetitive work does not often occur ; and, secondly, the carrying to completion of a project is the joint job of consulting engineer and contractor, each having his peculiar needs not found to the same extent in other branches of engineering. The conference therefore is to refer only to "The Place of the University in the Education of Civil Engineers" and it will be held from September 8 to 12. Professor Pippard, senior vice-president of the Institution of Civil Engineers, will take the chair at the first session.

It is not possible, of course, to discuss the whole field of civil engineering education in a conference of this kind. Pre-university education and the attainment of professional qualifications will not therefore be included. There will be a discussion of undergraduate study and the university curriculum, from the viewpoint of both universities and employers. There is a tendency amongst many lecturers in civil engineering to try to lighten the course by cutting out some of the more specialised work. If this tendency is approved it might lead to an increased

demand for post-graduate courses. This is a subject which cannot be studied without the co-operation of engineering employers, so a discussion of post-graduate courses has been included. There will also be a discussion on the place of civil engineering research in the university. There is no doubt that a live school of research is essential to the well-being of a university civil engineering department, but this is only possible if its value is recognised by practising engineers who can encourage research by proper recognition of research degrees, and by bringing their more fundamental problems to the attention of the universities. Each of these main topics will be introduced briefly by eminent practising engineers and university representatives. Many of these problems have been faced in the United States and for this reason Professor Newmark, head of the Department of Civil Engineering, University of Illinois, has been invited to take part in the discussions. Considerable support has already been given to this conference but we understand that at present the proportion of practising engineers to the university representatives is rather low. Anyone wishing to take part in the conference should write to the Organising Secretary, Civil Engineering Department, Queen's University, Belfast.

TECHNICAL LIAISON SERVICE

We are sometimes driven to the conceited conclusion that we know a great deal more than other people. In fact, of course, in a special kind of way, we probably do ! For if we need editorial information we seldom have much doubt where to look for it and even when we are in doubt, we have pretty sound ideas about who else will be likely to know. Much the same condition rules, no doubt, in other organisations besides the editorial departments of technical journals. For example, a research establishment that does not know how to set about getting hold of information from elsewhere relating to its specific field is just not worth its salt. It follows that we, and also, of course, such research establishments, are repeatedly surprised to find that there are plenty of people apparently wholly unaware of the existence of sources of information which have been known to us for years. Indeed, we have to guard against the acquirement of a feeling of contempt for those who prove so ignorant. For, after all, it is our job to be in constant contact with sources of information. But that of a small firm may be to make a very limited range of goods by well-tried methods, so that when some design or production problem, or, for that matter, one concerned with the sales or financial side, does turn up, those in the firm need feel no disgrace in confessing that they do not know where to turn for help. If any disgrace is involved it surely lies with the community as a whole through its failure to recognise that a need may exist for organisations to which such firms can appeal.

That these are not idle musings upon our part is demonstrated by a booklet now in our hands descriptive of an experiment carried out for the Scottish Council (Development and Industry), and supported by the D.S.I.R. with counterpart funds derived from U.S. economic aid. The full report is obtainable from the council at 1, Castle Street, Edinburgh. What the council did was to set up a Technical Liaison Service (T.L.S.), consisting of three retired engineers, and send them out to visit over 100 small firms with less than 500 employees to find out whether they were confronted with any problems in striving to expand and become more efficient ; how they were tackling them ; and how external services could help. What they actually discovered was that most of these firms were finding great difficulty in solving their problems, often, indeed, abandoning the attempt, and that they relied predominantly on trade contacts for information and were accordingly in danger of operating within a closed circle. They also found that information leading to a solution of 70 per cent of the problems was already in existence somewhere, but that the sources of the knowledge were unknown to, or had not been approached by, the firms concerned. Some of the queries could, indeed be answered outright and at once by the T.L.S. team, others as quickly by the Scottish Council, the D.S.I.R. Technical Enquiries Service, the Canadian Technical Information Service, various research laboratories and technical colleges. For other problems the T.L.S. was able to put the firms concerned in touch with organisations which could handle technical or design problems, do sponsored research, or provide business information or financial help. The very reasonable conclusion reached by the steering committee of the council is that some kind of permanent technical liaison service ought to be established and it suggests that the operation of a regional scheme " belongs properly " to the D.S.I.R. In the meanwhile, we gather, under impulsion of the committee, the Scottish Education Department has authorised the expenditure required to set up a Technical Information Service under the Department of Industrial Administration at the Royal College of Science and Technology at Glasgow. The D.S.I.R. is giving consideration to the project.

WORK STUDY IN THE ROYAL NAVY

The growing cost of ships and equipment and the strategic changes in the past few years have necessitated a redesign of the whole pattern of the Royal Navy's shore support to meet modern needs. The aim has been to economise on overheads and running costs and to amalgamate and concentrate wherever possible. Dockyards, Commands, bases, naval air stations, hospitals and shore depots have all been affected. Several of these establishments have been, or are being closed down, or amalgamated with others, and both the Controller's Department at the Admiralty and the Royal Dockyards have been completely reorganised on the same general principle. Instead of being divided into specialised professional sections, the department for which the Controller is responsible will now be divided under broad functional sub-divisions—ships, weapons and equipment. Similarly a General Manager is being appointed for each Royal Dockyard under the authority of the Admiral Superintendent. He will have under him departments carrying out specific tasks instead of the dockyard being divided up, as hitherto, according to the profession of the individual —construction engineers and electrical engineers.

Moreover, with the object of obtaining the maximum operational and administrative efficiency both ashore and afloat, the Royal Navy has followed the example of several individual firms, and a year ago set up a " work study " organisation. A training school modelled on the work study instructional department of an international commercial undertaking, was opened recently at the Royal Naval Barracks, Portsmouth, by the First Sea Lord who was mainly responsible for the introduction of work study technique into the Royal Navy. Courses vary in length from one to six weeks and it is hoped to have twelve teams at work in ships and shore installations by the end of this year. As far as can be seen at present,

50 per cent of their work is likely to be concerned with organisation and with what might be called "chores," and about 25 per cent on maintenance problems. There are now four teams under way—each consisting of two Lieutenant-Commanders with a Chief Petty Officer as a recorder-analyst—and already considerable success has been achieved in various fields in the saving of time and manpower. One of the earliest successes was the result of motion study work by a combined naval and scientific team. This team proved it was possible to increase by 88 per cent the number of rounds a minute fired by a twin 4in anti-aircraft gun, while at the same time reducing the gun crew by 23 per cent. Another team investigated the possibility of reducing the time taken by a shallow water diver to dress, a matter which is sometimes of considerable operational importance. It succeeded in greatly reducing the time factor by devising a scheme to ensure that diving suits are prepared in advance for being put on quickly. Work study units have been no less successful on the administrative side. On their recommendation new sorting routines with specially designed equipment have been introduced, at negligible cost, in two mail offices at large naval establishments. This has resulted in a 60 to 75 per cent reduction in the number of staff and a financial saving of £10,000 a year in the combined cost of running the two offices. Much indeed is hoped of the Navy's "work study" organisation, particularly in eliminating unnecessary "chores" and ensuring that essential routine tasks are carried out quickly and smoothly and, where possible, by fewer men.

DO SAFETY POSTERS WORK?

About four months ago we welcomed and commented upon the decision of the Accident Prevention Committee of the British Iron and Steel Federation to publish, approximately at four month intervals, an attractively printed journal called *Safety*. The June number which lies before us as we write contains amongst others an article on "Do Safety Posters Work?" We have ourselves always wanted to know, because like plenty of other people, we suspect they don't! It is not altogether a very easy question to answer because if one starts asking questions of individuals who ought to be influenced by the posters there is the probability that temporarily they will be made more poster-conscious than usual. However, two companies in the iron and steel industry somewhat ingeniously arranged for a recent period to exhibit three times as many posters as usual, subsequently inquiring of some employees which posters they considered the most effective. For those who devise posters, who arrange for their showing and who believe them to be really effective, the answer was somewhat deflating. With only occasional exceptions the answer to the query appears to have taken some variation on the theme "What posters?" That discovery, that people seldom really notice posters, though recorded in rather more definite terms than usual, is of course, not wholly new. For within industry (and outside it, too, as for example in posters relating to road safety) there has been, in recognition of the doubtful efficacy of posters, discordant argument as to whether safety posters should be humorous, horrific or merely shocking in order to attract attention. The fact that no type has ever been proved even vaguely more successful than another suggests depressingly that nobody takes much notice anyway; and even the fact that a certain horrific road accident poster did for a time attract a great deal of notice is not an effective argument. For people noticed the poster because they objected to such a thing being exhibited. There is no evidence whatever that it had any influence upon the behaviour of any road user; only that people objected to being assaulted by weeping widows at every street corner!

Should then, firms give up using safety posters? We must say we do rather wonder sometimes whether accident prevention would be furthered if they were to do so. For in too many factories the management feels its duty is as well done as it could be done so long as it can say it exhorts its employees to be safe by exhibiting safety posters and slogans. In fact, of course, as many a safety officer proves fond of quoting "No poster ever prevented an accident." Much more positive action is needed, stemming from the active interest of the board of directors itself, if the accident rate in any factory is to be brought down. Thus, were posters not available, certain backward companies might be forced into thinking more clearly about steps they ought to take more actively to promote safety. But to suggest in that way the idea that posters should be abolished is also to shock the mind into a realisation that they really must have some value, which is not brought out by the kind of investigations related here. For were a company manufacturing, let us say a cereal, to run for a short while an intensified poster advertising campaign and then to ask people at random in the streets which poster they liked best, would they not also get predominantly the reply "What posters?" Yet the commercial value of poster advertising has again and again been demonstrated financially. Thus whether or not employees of a firm "observe" safety posters there will, we believe, be exerted an influence on their minds. The effect no doubt is similar to that of subliminal advertising on television. Whether they realise it or not they become more safety conscious.

The Engineer — 100 Years Ago (JULY 16, 1858)

"BURGESS AND KEY'S REAPING MACHINE."

"The M'Cormick reaping machine, as improved and manufactured by Messrs. Burgess and Key, of Newgate-street, London, comes to the exhibition of this year with a prestige of having beaten all others on former occasions. It will be remembered that, in the judges' report of the results of the trials at Leigh Court, it is said that this machine cuts a clear track of five feet six inches; that in every operation in which it was tested it exhibited a decided superiority; that it cut with great precision both wheat and barley, standing and partially lodged—and, in cutting through weeds and grass showed no tendency to choke; and that the delivery is peculiar to this machine, and is the principal and most important improvement effected since last year, the corn, on being cut, falling on a series of rollers, fitted with Archimedean screws, by which it is delivered in a continuous and well-formed swathe at the side of the machine. It is further stated that this delivery, being effected by the machine, dispenses with the attendant necessary in Dray's and Palmer's machines; and it was proved to be capable of cutting wheat and barley with no other attendance than a boy strong enough to drive a pair of horses.

"The draught, also, was said to be much lighter than that of any other machine, and the horses were not required to travel faster, or to exert greater power than would be necessary in ploughing in land in medium strength. In the same report it is said that the superiority in cutting in this machine appeared to be the result of a larger stroke in the knife, equal to 5½ inches; and the reduction in draught and speed the consequence of a more correct calculation and distribution of power. The judges had no hesitation in awarding to this machine the (Royal Agricultural) Society's prize of £30, and they felt assured that all who witnessed the trials would concur in that decision."

North of Scotland Hydro-Electric Schemes

No. IX: THE BREADALBANE SCHEME — PART II*

A general picture of the Breadalbane group of schemes was given last week. Here we describe the principal dams of the scheme. Three buttress dams have been built with fly ash concrete; Lednock dam, above, is designed to resist earthquake stresses, and Giorra dam is being constructed in 10ft lifts. Lubreoch and Giorra dams show successive refinements in design over the prototype gravity buttress dam as built at Loch Sloy and Lawers. Breaclaich dam is the Board's second rock-fill dam, and is noteworthy for the simplicity of its construction.

THERE are five major dams in the Breadalbane scheme, which are at present completed or at a fairly advanced stage of construction. One, at Breaclaich, is a rock-fill dam, and the others are all concrete buttress structures. The Lawers dam, which was completed some years before the others, is virtually a replica of the dam at Loch Sloy, but its maximum height is less. Lubreoch and Giorra dams are gravity buttress designs, of the same family as the Sloy dam, but with improvements over the Sloy design. Lednock dam is a diamond-headed buttress dam, of a design rather different from any other of the North of Scotland Hydro-Electric Board's dams.

These last three have in common the use of fly ash in their construction. Our last article in this series gave details of the methods used in the Garry and Moriston schemes to economise in the consumption of cement, the supply of which had been causing the Board certain difficulties. We explained how blast-furnace slag had been used in the Trief process to eliminate about 70 per cent of the content of cement otherwise needed for two of the dams of the scheme. As part of the same policy, the rock-fill dam at Quoich was built. At Breadalbane we have further examples of that same general policy in the construction of the Board's second large rock-fill dam and in the use of fly ash, as an alternative economy to the Trief process, at Lednock, Lubreoch and Giorra dams. The Trief process has, in fact, been used at Breadalbane as well, in certain of the outlying concreting works needed to build the aqueducts, but the use of fly ash has been the principal economy sought.

Braehead power station has been the source of the fly ash: it is brought to the dam sites in bulk, and treated simply as an additional material to be added to the concrete at the batching plant. At one plant it is lifted to its storage hopper by an elevator which also handles the cement, but it must be stored and weighed as a separate constituent, and additional equipment must be installed at the batching plant to do this. It is tested on site for carbon content and rejected if a figure greater than 10 per cent is obtained; both the strength and colour of the finished work are affected by the carbon content. Care must be taken to keep the fly ash dry and avoid condensation in its containers, if it is to be handled easily. Only small quantities of the ash can be stored, as it tends to compact if left any length of time. It is added to the concrete mix in a quantity sufficient to replace about 20 per cent of the cement which would otherwise be used. The concrete is indistinguishable in appearance from normal Portland cement concrete. However, the fly ash is very subject to change in carbon content with the use of various coals at the power station; at Braehead coal from a large number of sources was used.

The cementing properties of the fly ash are given by its high content of silica, which combines with the lime set free when the Portland cement sets. The properties of the resulting concrete are modified by a reduction in strength at early ages, but after the initial delay the strength of the fly ash mix tends to approach that of the normal mix with increasing age, until there is generally little difference in strength at an age of one year. The heat of hydration is reduced by the fly ash additive, and apparently this has been the principal advantage sought in its use in dam construction in the U.S.A., rather than the direct saving in cement aimed at by the Board. For the Scottish dams impermeability to the aggressive highland waters is considered to be the over-riding criterion for the concrete, so facing concrete has tended to be rather rich in cement. The reduced heat of hydration, and hence reduced tendency for shrinkage cracks to form, which the fly ash mix gives, is favourable in this respect, particularly since for the same water content as ordinary Portland cement concrete, workability is improved by the addition of fly ash. Further, dams are not generally subjected to full water loads until the concrete has been in position for some time, so the fly-ash concrete can mature before its impermeability is put to the test.

A thorough investigation of the properties of the fly ash concrete was considered necessary before it could be used on any of the Board's dams, particularly since the conditions governing its use were quite different from those in the U.S.A. where previous experience was available. Research was therefore carried out by Professor W. T. Marshall at the University of Glasgow, and a detailed account of the problem has been given in a paper by Messrs. Fulton and Marshall.*

Since that account was published the Lednock dam has been completed and its reservoir filled, and construction has advanced very considerably on Lubreoch and Giorra dams, and Lubreoch dam is now retaining water to an intermediate level. Lednock dam has shown itself to have a high standard of watertightness. Details of the mixes of the fly ash concrete used for this dam and the strengths obtained at various ages are:

	Hearting concrete	Rich facing concrete
Aggregate/cement ratio	9 : 1	6·3 : 1
Per cubic yard :		
Portland cement, lb	305	440
Fly ash, lb	76	76
Dry sand, lb	1098	1040
Dry 3in–1¼in aggregate, lb ...	1167	1104
Dry 1¼in–⅜in aggregate, lb	1167	1104
Water, lb	229	258
Strength :		
28-day minimum requirement, lb per square inch	2300	2800
Mean cube strengths from statistical analysis of works cubes tested, lb per square inch	2930	3840

More recent information on the use of fly ash, with more detailed reference to the Breadalbane dams, is given in the correspondence to the paper referred to above, published in the Institution of Civil Engineers' *Journal* for July, 1957. Furthermore, three papers on this subject are to be presented by British authors at the forthcoming congress on large dams, to be held in New York in September; these three include the paper "Use of Fly Ash at Lednock Dam" by Messrs. R. H. McDonald and A. C. Allan.

Some 3000 tons of fly ash was used at Lednock dam, replacing 20 per cent of the cement in 78,000 cubic yards of concrete. A saving of £17,000 has been claimed by the use of fly ash at Lubreoch dam, even though it was not used in the early stages.

* No. VIII, The Garry and Moriston Schemes, appeared October 5–November 9, 1956.

† The actual catchment areas utilised total about 202 square miles.

* "The Use of Fly Ash and Similar Materials in Concrete," *Journal I.C.E.*, November, 1956.

Lednock Dam

The structural design of buttress dams, as exemplified by recent work in Scotland, was discussed quite fully in a recent article in this series (on the Tummel Garry scheme, when Errochty dam was described in THE ENGINEER of September 9, 1955). At that time, we showed comparative cross sections of various buttress dams, and figures of principal stresses, and enumerated the advantages claimed for these designs over the solid gravity dam, principal amongst which is a saving in concrete.

The Lednock dam is rather different from any of those previously discussed. It will be seen from the accompanying drawing that the dam is a diamond-headed buttress structure ; but unlike other buttress dams in this category, its upstream face is not markedly sloped, but approaches verticality. Thus in design concept it appears to lie halfway between the " gravity buttress " concept of the Sloy dam—achieved by " opening out " a gravity dam—and to the classical buttress dam as analysed by Noetzli and Schorer, and as expressed in Scotland by Shira and Errochty dams. This characteristic shape of Lednock dam is considered by the consultants to give the most economical structure for the particular conditions encountered. It was decided upon after an extensive comparison in which over forty different buttress shapes were analysed.

The dam is also rather more massive than comparable Scottish buttress designs. This is due to a special peculiarity of its site. Comrie, the village nearby, has experienced earthquakes, principally three in the period 1839 to 1848, two of which reached an intensity of eight on the Rossi–Forel scale. The village lies close to the Highland border fault, with which the earthquakes are associated ; their epicentre has always been localised within a small area round the village, the intensity of eight just mentioned being recorded up to 6 miles from the epicentre. This radius, however, takes in the site of Lednock dam. The design of the dam therefore includes a provision for earthquake shock, being the horizontal force due to an acceleration of 0·075 *g*.

Apart from the problem of design of the buttress dam itself, three other alternatives were considered at the design stage, namely gravity, earth- and rock-fill dams. Estimates of the buttress and earth-fill designs were so close that both designs were prepared in detail, and explorations made to confirm the sources of fill and clay puddle for the earth dam project. The latter was included as an alternative in the tender documents, and did in fact attract the second lowest bid.

Each buttress of the dam has a stem which is thickened to 20ft along the downstream face, giving an effect analogous to the flanged thinner web of a beam. Corners are rounded to avoid stress concentrations, and the dam is corbelled out near the top so that the roadway along the crest has been formed by the main *in situ* concreting, with no precast work.

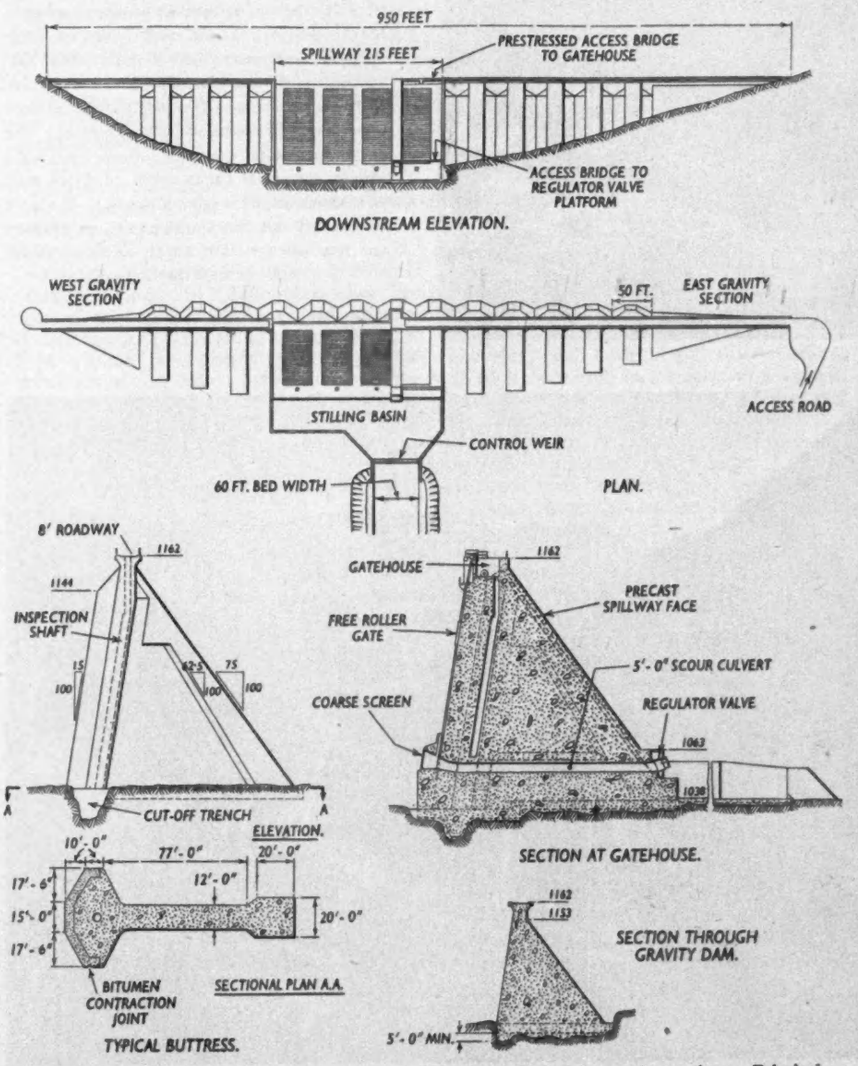
The buttresses of the dam are statically independent, but each one abuts directly on to the next. The sealing strips conventionally used at joints in a dam are not employed here. A plug of bitumen 1 square foot in cross-sectional area and 2ft 6in from the upstream face extends from crest to bedrock between each pair of buttresses, and in it a pipe is inserted, so that the bitumen can be heated by steam, and thus softened so that it flows and makes a watertight joint. There is also an inspection shaft in the head of each buttress. Considerable attention must be paid to the cut-off in a buttress dam : at Lednock vertical drains are drilled into the rock behind the cut-off wall ; these drains discharge into the spaces between the buttress webs.

The intake to the main tunnel is on the right bank of the reservoir, well away from the dam. The only water control arrangements embodied in the dam therefore are the spillweir and a scour culvert. The latter is 5ft in diameter and is controlled by a discharge regulator and a small needle valve which bleeds off the compensation water. There is a free-rolling emergency gate on the upstream side of the culvert. Both valve and gate are electrically operated, and both the gate-house at the crest, and the valve house on the downstream side are situated largely within a hollow in the main body of the dam. The spillweir is formed from precast concrete beam elements spanning between the buttresses ; it will pass 5300 cusecs at a head of 3·6ft. There is a step in the spillweir crest, which forms a horizontal walkway. This configuration was assessed with a hydraulic model. Posts for a handrail can be fixed in sockets left on the upstream side of this walkway, so if any maintenance is necessary, the work can be approached along the walkway. There is no road access on the far side of the dam, and no access bridge has been necessary, as a result of this expedient.

The effect of the earthquake forces acting in the same direction as the water load can be judged from the following figures. The maximum vertical compressive stresses at the base of the dam are :

	Reservoir empty, tons per square foot	Reservoir full, tons per square foot
Upstream face :		
Without earthquake allowance	7·78	2·32
With earthquake allowance...	7·08	1·07
Downstream face :		
Without earthquake allowance	2·74	10·76
With earthquake allowance...	3·73	12·57

The uniqueness of the problems of any one site, differing economic conditions at the time of construction, and differing requirements for ancillary features, such as the crest roadway, all militate against an exact comparison between the merits of different dams. Such a comparison has been made, however, in the case of Sloy, Lubreoch and Giorra dams in a paper by Messrs. E. J. K. Chapman and D. F. Campbell,† where these structures were also compared with two gravity dam designs. Referring all these to a section of dam with a height of 120ft the paper gives the concrete in cubic yards per lineal foot respectively as 209, 140, 136 and 119 for a gravity design and for the Sloy, Lubreoch and Giorra design ; shuttering in square yards per lineal foot is 41 (54 in the second

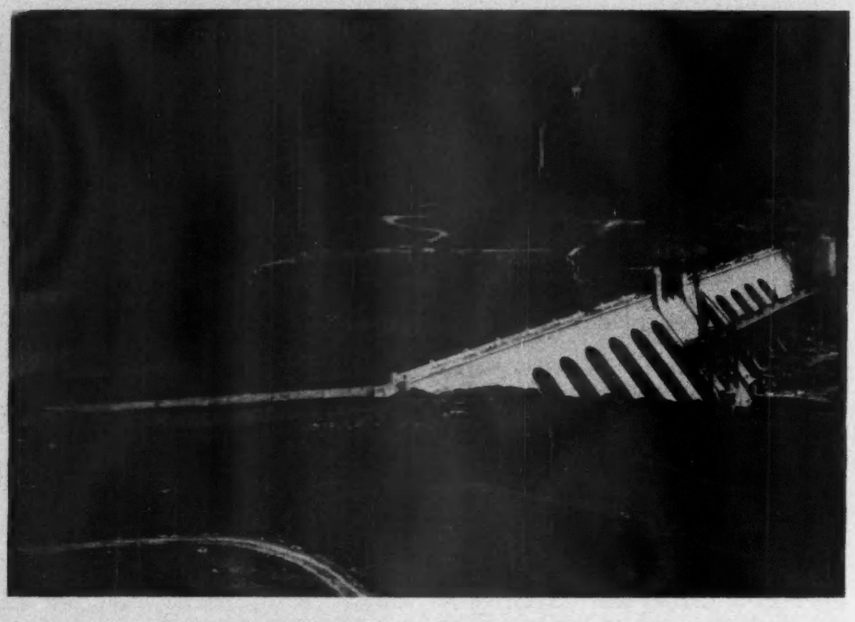


Lednock dam. There are thirteen buttresses, each 50ft across, flanked by gravity sections. Principal dimensions of the dam are : crest length 950ft ; height above river bed 106ft; volume of concrete 100,000 cubic yards

† " The Design and Economics of Massive Buttress Dams," Paper R.61, Fifth Congress on Large Dams, Paris, 1955.

Massive Buttress Dams

Three stages in the evolution of the class of dam known as the "massive buttress" dam, are depicted here. Constructional speed and simplicity have been primary aims in developing these designs, which are discussed in the accompanying article. All three dams are part of the Breadalbane scheme. The earliest, the Lawers dam, shown OPPOSITE, was completed in 1957, and is generally similar though not so high as the prototype of this class, which was built at Loch Sloy and completed in 1950. The Lawers dam has a maximum height of 130ft and a crest length of 1250ft.



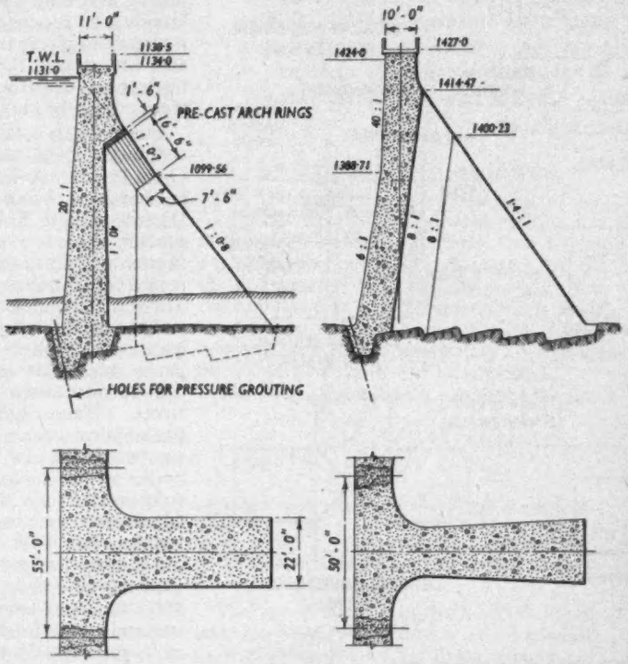
Lubreoch dam (LEFT) is slightly more economical in constructional quantities than the Sloy design. Note that the contraction slots between buttresses are carried right up to the crest of the dam, above the precast concrete arches, which carry the roadway on the downstream side. These arches are shallower than in the earlier dam. The illustration shows the gate houses under construction ; one controls a gate for the scour culvert, the other a gate for the power station intake. The gate shaft is, in each case, in the body of the dam. There are syphon spillways below each gate house. Precast concrete elements have still to be placed on the crest to form the roadway

Giorra dam, part of which is shown under construction on the RIGHT, represents the third stage in refining the massive buttress design. By altering the slopes of the buttress head, the precast arches have been eliminated. Comparative quantities are less than for Lubreoch dam. The spillweir is formed by building a length of open-jointed gravity dam, in contrast to the precast concrete planking which spans between buttresses in the earlier dams

Lubreoch dam has a maximum height of 130ft above foundation level, and a crest length of 1740ft. Corresponding figures for Giorra dam are 110ft and 1540ft. The consulting engineers for all three dams are Messrs. James Williamson and Partners. The main contractors are, respectively, the Cementation Company, Ltd. (Lawers), James Miller and Partners, Ltd. (Lubreoch), and Edmund Nuttall Sons and Co. (London), Ltd. (Giorra)

gravity design), 48, 54 and 51. The Lednock design is not exactly comparable, as we have indicated above (in particular the parapet and roadway design differs), but as near as can be judged we find that for a lineal foot of section 120ft high, the concrete volume would be 150 cubic yards and the shuttering 58 square yards ; if the provision for earthquake loads is omitted, the corresponding figure for the concrete is reduced to 134. Practically all the shuttering of the Lednock design is straight, and shuttering costs for the cross sections appear to vary little between Lednock, Lubreoch and Giorra. Thus, if allowance is made for the earthquake loads, this approximate comparison seems to indicate that the economy of the Lednock design is about midway between the Lubreoch and Giorra designs, the latter being the cheapest. The total variation over the three in this comparison is less than 10 per cent ; however, the cost of a comparable gravity dam appears to be about half as much again as the mean cost of these three.

The appearance of the finished Lednock dam is impressive, both in the architectural effect which the structure gives, and in its setting in the Lednock valley and its surroundings. An account of the constructional procedures used in building the dam has been given, together with a general description of the St. Fillans section of the Breadalbane scheme, in a paper presented to the South West Scotland Association of the Institution of Civil Engineers by Mr. W. McCready in March, 1956. The consulting engineers for the dam were Sir Murdoch MacDonald and Partners, and the contractors Taylor Woodrow Construction, Ltd.



Typical buttress details of (left) Lubreoch and (right) Giorra dams. Giorra dam is shown with a 10ft roadway

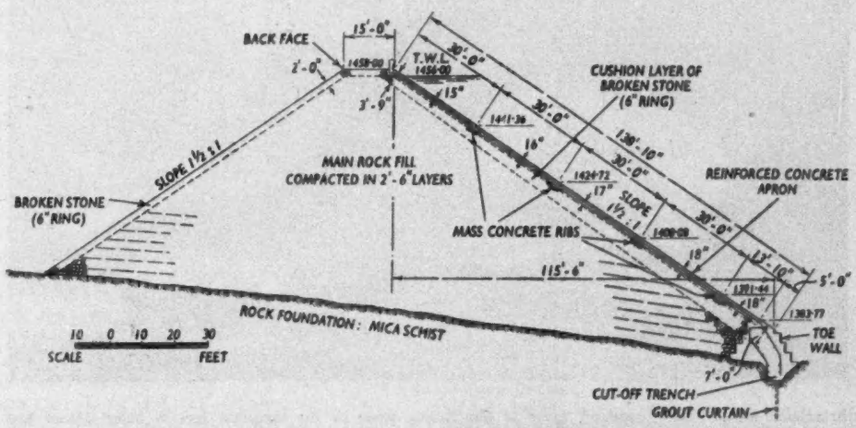
Lubreoch Dam

Lubreoch dam is similar in general form to the well-known dam at Loch Sloy, though its height is less, and it embodies certain design modifications. The drawing here shows Lubreoch dam in detail. The buttresses are at 55ft centres, and are separated by tapered plugs of concrete which are cast after most of the early contraction of the main concrete has occurred. These " plugs " are taken right up to the crest of the dam. So the precast arch rings which carry the crest on the downstream side (the depth of the arches formed by these rings is much reduced over the Sloy design) have their top surfaces coated with bitumen, and the arches and all work above them are free to move as the buttresses contract, until the plugs are filled after the stipulated interval of three months. The plugs each have three " water barriers " on each side, each in the form of a keyway, the first with a p.v.c. strip placed across it, the second bitumen-lined, and the third a plain keyway. Precast concrete is also used for the roadway where large L-shaped elements, each weighing 5·8 tons and 15ft in length, are placed one on each side of the dam, to form the road surface and parapet wall. The spillway is formed from prestressed precast concrete beams spanning between buttresses, but a cast *in situ* topping is added, using a vacuum shutter, to take the live load for which the spillway is designed. The length of spillway needed to cater for the design flood has been reduced by constructing two syphons. There are two buttresses of slightly more massive section than the others, one on each side of the spillway. Each one contains a syphon, and draw-off culverts, one being the intake to the small power station immediately below the dam, and the other a scour culvert controlled by a discharge regulator. These water-control devices are explained more fully in the next part of this article.

The compensation water flows from Lubreoch dam are quite substantial—55 cusecs, increasing to 78 cusecs in the summer period. Flow from the reservoir, it will be recalled, passes down the river for 3 miles to the headpond at Stronuich, where the intake to the main power station is situated. The 4MW Kaplan set at Lubreoch—identical in design with the set at Dalchonzie—utilises the head made available by the dam and takes a flow of about 650 cusecs. Compensation flow is discharged through a needle valve connected to a branch from the scour culvert.

10ft lift of steel shuttering in position at Giorra dam

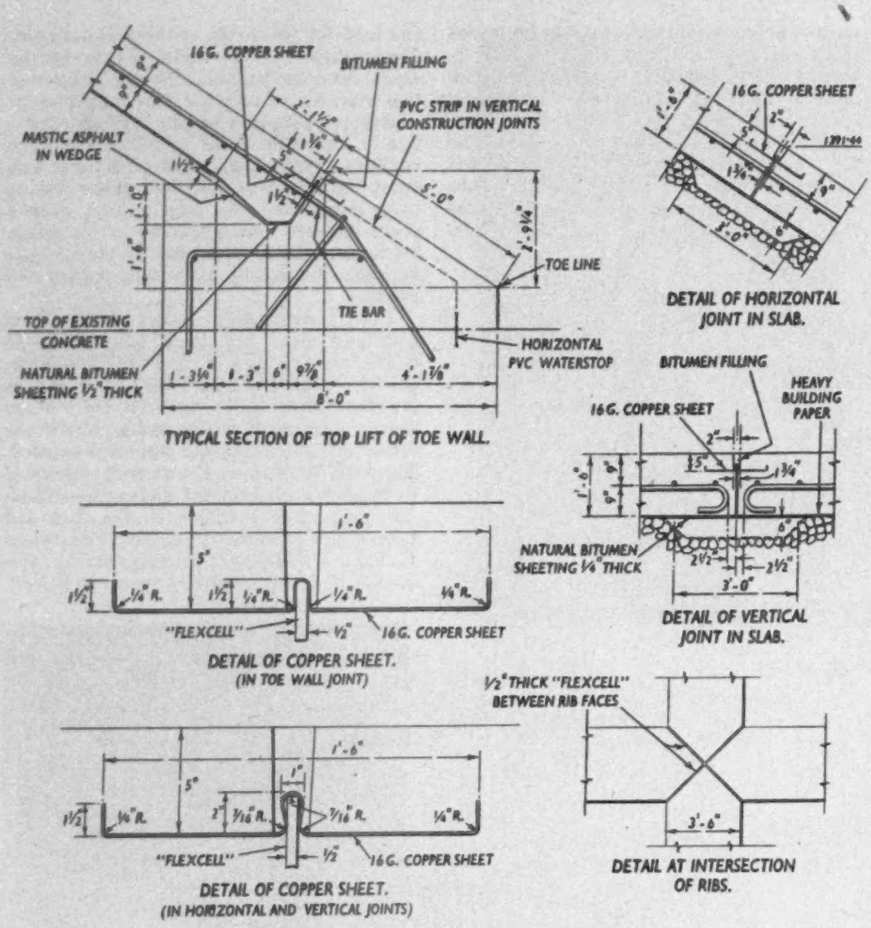
Concrete aggregate for the dam (and also for Giorra dam) is obtained from a quarry 6 miles down the glen, and brought to stockpiles on the site by lorry. A tunnel with a conveyor passes under these stockpiles, serving the concrete batching and mixing station, which is a modern plant with an output of 80 cubic yards per hour, capable of manual or automatic operation. There are eight constituents in the concrete mixes, namely, 2½in, 1½in and ¾in aggregates ; rock sand ; natural sand, cement fly ash and water. A secondary crusher is installed at the quarry to increase the yield of sand, 80 per cent of rock sand being used in the concrete. Part of the finer fraction of the rock sand is rejected at the quarry. The arch rings are precast on the site, but other precast elements are brought from a factory at Glasgow. The facing concrete has 480 lb of cement and 120 lb of fly ash per cubic yard ; corresponding figures for the hearting concrete are 336 lb and 84 lb ; minimum cube strengths of 2100 lb and 1350 lb per square inch are specified for the two mixes respectively.



Typical cross section of Breaclaich dam. Its height is 76ft; length 1400ft and volume 260,000 cubic yards

Giorra Dam

Both the design and construction of Giorra dam offer unusual interest to the civil


16G. COPPER SHEET
BITUMEN FILLING
PVC STRIP IN VERTICAL CONSTRUCTION JOINTS
MASTIC ASPHALT IN WEDGE
TOE LINE
TIE BAR
TOP OF EXISTING CONCRETE
HORIZONTAL PVC WATERSTOP
NATURAL BITUMEN SHEETING ½" THICK
TYPICAL SECTION OF TOP LIFT OF TOE WALL.
16G. COPPER SHEET
DETAIL OF HORIZONTAL JOINT IN SLAB.
BITUMEN FILLING
HEAVY BUILDING PAPER
16G. COPPER SHEET
NATURAL BITUMEN SHEETING ¼" THICK
DETAIL OF VERTICAL JOINT IN SLAB.
"FLEXCELL"
16G. COPPER SHEET
DETAIL OF COPPER SHEET. (IN TOE WALL JOINT)
½" THICK "FLEXCELL" BETWEEN RIB FACES
"FLEXCELL"
16G. COPPER SHEET
DETAIL OF COPPER SHEET. (IN HORIZONTAL AND VERTICAL JOINTS)
DETAIL AT INTERSECTION OF RIBS.

Constructional details of upstream apron of Breaclaich dam

engineer. The design was conceived, as we have already indicated, as a further refinement over the Lubreoch and Sloy designs, and the volume of concrete under comparable conditions has been reduced beyond that achieved in these earlier examples. Constructional simplicity was especially sought by the designers. Thus, the precast arches so prominent in the earlier dams of this type have been eliminated by adjusting the upstream slope, as is shown in the accompanying drawing. The change on the upstream face offers no special difficulty in shuttering, and the only special shutter needed is for the elliptical curve, where it can be used repetitively for a large number of times. Design of the dam has been explained, step by step, in some detail in the paper by Messrs. Chapman and Campbell, to which we have already referred, and which shows that the economies have been introduced without undue stress increases. The horizontal sliding factor is, however, high at 0·845 (i.e. the resultant force on a horizontal section at the base would act at an angle of 40 deg. 12 min. to the vertical), but the rock on which the dam is founded—granulite—is of good quality and is stepped and sloped at formation level, so resistance to sliding is considered adequate. One further simplification has been made in the shape of the dam since the paper was written ; originally, the web or stem of the buttress was 15ft wide for a distance of about 40ft, and then splayed out to 22ft at the toe. The splay is, in fact, taken from the tangent point, in the dam as built, thus giving the buttress straight sides at the expense of a slight addition in concrete.

Simplicity is again evident in the construction of the spillway, where the dam is, in effect, an open-jointed gravity dam ; an increase in hearting concrete has thus been accepted in preference to the precast planking characteristic of the spillways of other buttress dams. The intake of the tunnel to Cashlie power station is incorporated in the dam, with its guard gate and control gate. The scour culvert is similar to that at Lubreoch, but in this case no compensation flow is required, and the spillway provision is less onerous, since the proportional storage in this upper section of the scheme is much greater.

The simplicity in construction sought in designing the dam has been taken advantage of by the contractor in several ways which differ from normal practice. First, blasting and excavation were carried out largely in the first summer of construction before concreting was started ; the concreting itself was concentrated upon thereafter. The usual procedure of diverting the river in the first stages of construction, and then moving it back to flow through an opening in the dam was also obviated. A flume of steel plating was built (with the small section of foundation concrete immediately beneath it already in place) across the axis of the dam, and the stream flows through this flume throughout construction. The hole left in the dam will be plugged on completion.

Concreting is carried out in 10ft lifts. This is thought to be an innovation, at least in Great Britain. A similar height of lift—3m—is, however, being used on the Grande Dixence dam in Switzerland, and Canadian practice seems to favour very high lifts. The shuttering is illustrated. The elliptical shutter is formed of steel ribs, and is massively built. The straight shutter is not a climbing shutter and the assembly is tied together at the top level ; it is bolted at the bottom level, by patent bolts cast into the concrete, which can be withdrawn when the shutters are struck. These heavy shutters, especially the elliptical one, were at first found rather cumbersome in use ; the deflection induced by the wet concrete, for instance, had to be compensated for in the next setting. To allow adjustments such as this, tie rods and turnbuckles were built into the shutter, which can thus be strained into adjustment.

In the lower part of the dam, a buttress lift is concreted in two sections, with a construction joint between them. An interval of twenty-eight days is stipulated between placing these two blocks, and of seven days before a block can be covered by the next lift above. When a certain height is reached, the entire lift is concreted in one operation ; in the concreting schedule at the site, this stage involves the largest single "pour" of concrete of about 700 cubic yards, which can be done in about ten hours with the plant installed. Simplicity is again the keynote in the site plant generally ; the concrete station serves a single 3 cubic yards mixer.

Concreting of the dam is proceeding rather faster than usual, and it is thought that the entire programme of concreting involving 90,500 cubic yards will take a period of sixteen months i.e. the dam will be finished by

Breaclaich dam. The "cushion" layer of 6in broken stone on the upstream face is being placed and compacted near the toe wall in the centre

September, 1958. This completion date is in advance of the scheduled completion of Cashlie power station, so the reservoir will have time to fill before power is generated. In contrast with the concreting, grouting is going very slowly, because the rock is finely jointed so that grout does not penetrate readily, even with an " intrusion aid."

The North of Scotland Hydro-Electric Board's consulting engineers for both the Lubreoch and Giorra dams are Messrs. James Williamson and Partners. The contractor at Lubreoch dam is James Miller and Partners, Ltd., and at Giorra Edmund Nuttall Sons and Co. (London), Ltd.

Details of the rock-fill dam at Lochan Breaclaich are shown in the illustrations herewith. We understand that the principal factor in the adoption of a rock-fill dam, as opposed to a gravity dam which was the only alternative considered, was the rising cost of cement; the estimated cost for the rock-fill dam was about 10 per cent greater than for a gravity dam, but it was estimated that at the rate of increase in cost of cement at the time the tender was placed, the rock-fill dam would prove more economical by the time that construction was complete. A further practical advantage has been gained in the ability to place rock-fill in very cold winter conditions, which is important on such a high site.

The dam is set on a foundation of mica schist after the removal of a sparse covering of peat and heather. A concrete-filled cut-off trench is formed at the upstream toe on which is superimposed the reinforced concrete toe of the dam; below the cut-off trench a grout curtain is formed to a maximum depth of about 100ft. Behind this toe broken rock is compacted in 30in layers with 3-ton vibrating rollers. The layers of rock-fill are slightly inclined towards the upstream face and each layer is sluiced with large quantities of water to ensure that all " fines " are washed into the interstices of the fill. The upstream face of the dam is covered with a " cushion " layer of clean stone broken to pass a 6in ring. This layer varies in depth from 5½ft at the base to 3½ft at the top. The top and downstream face of the dam are covered with a 2ft layer of stone to a similar specification. The rock and broken stone used in the dam, other than for concrete, is the local mica schist, quarried close to the right abutment of the dam, which is unusually hard and durable. Not more than 10 per cent of the stone must pass a ¾in mesh; the maximum size is limited only by the thickness of the layers of rock placed in the dam.

The apron on the upstream face consists of reinforced concrete slabs 30ft square. The reinforcement is arranged in a grid in the centre of the slab. The cross sectional area of reinforcing steel is from 0·5 to 0·6 per cent of the cross sectional area of the slab in each direction. Copper and P.V.C. water bars are used between the slabs. The reinforcing steel is carried across all horizontal joints of the slabs but is not across the vertical joints.

The axis of the dam follows three straight lines corresponding to a rock outcrop. The dam and its associated diversion works to the 5MW power station beside Lednock reservoir reverse the natural direction of flow from Lochan Breaclaich. The dam incorporates a scour culvert, with an access gallery, and a spillway at the right abutment. " Tournapull " machines have been used to load rock at the quarry and place it on the dam. Crushing is needed only for the " cushion " stone.

The consulting engineers for the dam are Messrs. Duff and Geddes in association with Mr. R. H. Cuthbertson. The main contractor is R. J. McLeod (Contractors), Ltd.

(To be continued)

Nuclear Reactor Dynamic Analysis

No. II—*(Concluded from page 47, July 11)*

To investigate the safety or control of a nuclear reactor requires analysis of the dynamic behaviour of the system following postulated disturbances or during particular operating conditions. This paper, presented to the Institution of Mechanical Engineers‡ by R. Parr, B.Sc., A.M.I.E.E., and D. V. Wordsworth, B.Sc†., derives equations for a static fuel thermal reactor, a static fuel fast reactor, and a circulating fuel thermal reactor. A method of analysis of component temperature variations is presented, with particular reference to a solid fuel-element with a sheath cooled on the outer surface. We reproduce the paper in abridged form.*

Fast Reactor with Static Fuel

TAKING a simple one-energy group as representative of the conditions existing in a fast-neutron reactor produces flux kinetic equations similar in form to those for the thermal reactor. In the design of a fast reactor, however, a deliberate effort is made to prevent the slowing down of fission neutrons and so the probability of leakage during slowing down can be neglected.

The form of the kinetic equations will be

$$\tau_0\frac{d\phi}{dt}=k_\infty\phi\left(\frac{\Delta k_{\text{eff.}}}{k_{\text{eff.}}}-\beta\right)+\sum_1^6\frac{\lambda_i D_i\epsilon p}{\Sigma_a} \quad . \quad (7)$$

together with equation (6) which is unmodified.

Thermal Reactor with Circulating Fuel

The use of fuel in a fluid, or fluidised, state has been proposed as a means whereby the heat rating of a reactor could be increased, and such a system is also attractive for producing a " breeder " reactor. In some such designs it has been suggested that the fuel should be circulated through the reactor core and an external heat-exchanger system, so eliminating the need for a separate coolant passing through the reactor core. To use the large quantities of heat generated in the core requires a fuel hold-up in pipes and heat exchangers which is large compared with the hold-up in the reactor core itself. As a result there is a possibility that an appreciable number of the delayed-neutron emitters will produce their neutrons in parts of the fuel system external to the reactor. Such neutrons will not contribute to the maintenance of the neutron balance in the reactor.

The circulation of the fuel will not significantly affect the flux distribution in the core and so equation (4) can still be taken as representing the time variation of flux at any point in the reactor. The delayed-neutron emitter density in the core will be affected by the fuel circulation. The equation representing the emitter density, D_i, at any point in the core, will now be

$$\frac{\partial D_i}{\partial t}+v\frac{\partial D_i}{\partial z}=\frac{k_\infty\Sigma_a\phi\beta_i}{\epsilon p}-\lambda_i D_i \quad . \quad (8)$$

Defining a mean value of D_i in the direction of fuel flow by

$$\bar{D}_i=\frac{1}{L}\int_0^L D_i dz$$

and integrating equation (8) along the z direction gives

$$\frac{d\bar{D}_i}{dt}+\frac{2v}{L}(D_{i_L}-D_{i0})=\frac{k_\infty\Sigma_a\phi\beta_i}{\epsilon p}-\lambda_i\bar{D}_i \quad . \quad (9)$$

As an approximation it can be assumed that

$$\bar{D}_i=\frac{D_{i_L}+D_{i0}}{2}$$

so giving

$$\frac{d\bar{D}_i}{dt}=\frac{k_\infty\Sigma_a\phi\beta_i}{\epsilon p}-\alpha_i\bar{D}_i+\frac{2v}{L}D_{i0} \quad . \quad . \quad (10)$$

where

$$\alpha_i=\lambda_i+\frac{2v}{L}.$$

On introducing mean values equation (4) becomes

$$\tau_0\frac{d\phi}{dt}=-L^2B^2\phi-\phi+k_\infty\phi(1-\beta)P_s(B^2)+\sum_1^6\frac{\lambda_i D_i\epsilon p P_d(B^2)}{\Sigma_a} \quad . \quad . \quad . \quad (11)$$

In the steady state $d\phi/dt=d\bar{D}_i/dt=0$ and substitution for $\bar{D}_i$ from equation (10) into (11) gives

$$-L^2B^2\phi-\phi+\frac{k_\infty\phi(1-\beta)}{1+B^2L_a^2}+\sum_1^6\frac{k_\infty\phi\beta_i\lambda_i}{(1+B^2L_a^2)\alpha_i}+\sum_1^6\frac{2v}{L}\frac{\lambda_i D_{i0}\epsilon p}{\alpha_i(1+B^2L_a^2)\Sigma_a}=0 \quad . \quad (12)$$

where once again it has been assumed that

$$P_s(B^2)=P_d(B^2)=\frac{1}{1+B^2L_a^2}$$

Nomenclature

A—Coolant specific heat.
B^2—Buckling.
C_m—Moderator specific heat.
C_s—Sheath material specific heat.
C_u—Uranium specific heat.
D—Diffusion coefficient.*
D_i—Delayed-neutron density (neutrons of type i).
D_{i0}—D_i in external circuit, at reactor exit.
D_{i_L}—D_i in external circuit, at reactor inlet.
$\bar{D}_i$—Mean D_i in external circuit.
h—Heat-transfer coefficient.
H—Heat production rate, per unit volume of material.
k_∞—Infinite multiplication factor.
k_c—Coolant temperature coefficient.
$k_{\text{eff.}}$—Effective multiplication factor in a finite system.
k_m—Moderator temperature coefficient.
k_u—Uranium temperature coefficient.
L—Reactor channel length.†
L_e—Extrapolated channel length, for neutron flux distribution.
L_t^2—Thermal neutron diffusion area.
L_s^2—Neutron slowing down area.
N—Neutron density.
p—Neutron resonance escape probability.
P—Reactor power; perimeter.
r—Radius.
S_c—Coolant channel flow area.
S_m—Moderator cross-sectional area per channel.
S_s—Fuel rod sheath cross-sectional area.
S_u—Fuel rod cross-sectional area.
t—Time.
t_c—Core circulation time in circulating fuel reactor.
T—Temperature.
v—Coolant velocity in core.
β—Fraction of fission neutrons which are delayed.
ϵ—Fast fission factor.
Σ_a—Macroscopic absorption cross section.
ϕ—Neutron flux.
λ—Decay constant.
ρ—Density.
τ_0—Mean lifetime of thermal neutrons.

* In this text, one-third of the transport mean free path.—Ed. The E.

† This should not be confused with the diffusion length, also impliedly denoted by L. The writers use only the diffusion area, L^2, in their treatment, while the square of the channel length does not appear.—Ed., The E.

* Reactor Engineering Department, A.E.I.-John Thompson Nuclear Energy Company.
† A.E.R.E., Harwell.

‡ Discussion is invited; communications to be received by July 31, 1958, at 1, Birdcage Walk, Westminster, London, S.W.1.

Equation (12) represents the steady-state neutron balance, the last two terms being contributions from delayed neutrons.

The "effective multiplication factor," $k_{eff.}$, as defined previously, will now be given by

$$k_{eff.}=\frac{k_\infty(1-\beta)+\sum_1^6\frac{k_\infty\beta_i\lambda_i}{\alpha_i}+\sum_1^6\frac{2v}{L}\frac{\lambda_i}{\alpha_i}\frac{D_{i0}\epsilon p}{\Sigma_a\phi}}{(1+B^2L^2)(1+B^2L_a^2)} \quad . \quad . \quad . \quad . \quad (13)$$

Introducing $k_{eff.}$ into equation (11) gives

$$\tau_0\frac{d\phi}{dt}=\frac{\Delta k_{eff.}}{k_{eff.}}-\frac{k_\infty\phi(1-\beta)}{(1+B^2L^2)}-\sum_1^6\frac{k_\infty\beta_i\lambda_i\phi}{k_{eff.}\alpha_i(1+B^2L_a^2)}-\sum_1^6\frac{2v}{L}\frac{\lambda_i}{\alpha_i}\frac{D_{i0}\epsilon p}{\Sigma_a k_{eff.}(1+B^2L_a^2)}+\sum_1^6\frac{\lambda_i\bar{D}_i\epsilon p}{\Sigma_a(1+B^2L_a^2)} \quad . \quad . \quad . \quad . \quad . \quad (14)$$

and this, together with equation (10) for the delayed neutron emitters, represents the time variation of the mean neutron flux for a circulating fuel reactor.

The delayed neutron emitter density D_{i0}, at the inlet to the reactor, will be determined by the fuel transit time in the circuit external to the reactor, and by whether or not a fuel processing system is used, resulting in the total removal of emitters together with the less desirable fission products.

Neglecting processing losses in the external circuit, D_{i0} will be related to D_{i_L} by

$$D_{i0}=D_{i_L}e^{-\lambda_i t_1}I \quad . \quad . \quad . \quad (15)$$

where

$$I=0 \text{ for } 0<t<t_1$$
$$=1 \text{ for } t\geqslant t_1$$

In terms of $\bar{D}_i$, the mean density in the reactor is given by

$$D_{i0}=\frac{2\bar{D}_i e^{-\lambda_i t_1}I}{1+e^{-\lambda_i t_1}I} \quad . \quad . \quad . \quad (16)$$

This expression for $\bar{D}_{i0}$ should be used in conjunction with equation (14) for the most general case when both the time and the magnitude dependences of D_{i0} on D_{i_L} are considered.

When fuel processing is employed it might be impossible to avoid losing some delayed neutron emitters with the other fission products. If such is the case it might be a justifiable approximation to neglect altogether the emitters which re-enter the reactor core, so reducing the flux equations to

$$\tau_0\frac{d\phi}{dt}=\frac{\Delta k_{eff.}}{k_{eff.}}-\frac{k_\infty\phi(1-\beta)}{(1+B^2L^2)}-\sum_1^6\frac{k_\infty\beta_i\lambda_i\phi}{k_{eff.}\alpha_i(1+B^2L_a^2)}+\sum_1^6\frac{\lambda_i\bar{D}_i\epsilon p}{\Sigma_a(1+B^2L_a^2)} \quad . \quad . \quad (17)$$

$$\frac{dD_i}{dt}=\frac{k_\infty\Sigma_a\phi\beta_i}{\epsilon p}-\alpha_i\bar{D}_i \quad . \quad . \quad (18)$$

On comparing equations (17) and (18) with the corresponding ones for a static fuel, equations (5) and (6), it will be seen that the principal effect of fuel circulation has been to change the delayed-emitter decay-constant from the natural value, λ_i, to λ_i+2v/L.

Reactivity Balance

As indicated above, reactivity balance is dependent upon the component temperatures. It is, in general, possible to assign to any component a temperature coefficient which indicates how the reactivity balance in the reactor will be influenced by changes in the temperature of that component. As the variation with time of the different core component temperatures may be widely different following a disturbance of some sort, it is important that the temperature coefficients of all components should be considered.

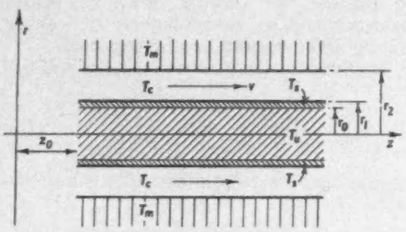
The relationship between reactivity at any time and component temperatures can be expressed as

$$\frac{\Delta k_{eff.}}{k_{eff.}}=f(t)+k_u(T_u-T_{u0})+k_s(T_c-T_{c0})+k_m(T_m-T_{m0}) \quad . \quad . \quad . \quad (19)$$

where $f(t)$ is a known function, allowing, say, for control-rod withdrawal. When the transients arise from heat-transfer sources only, then $f(t)=0$. Subscript 0 indicates temperatures before the transients occur.

Thermodynamic Analysis

The equations giving temperature at any time and position in the reactor can be obtained from a study of the heat balance equations. These are given below for a lattice system as shown in Fig. 1, consisting simply of a solid uranium rod enclosed in a sheath cooled on the outside. The channel is supposed to run through a solid moderator, and the assumption is made that no heat transfer occurs from the lattice considered to the moderator adjacent. In the equations the following system of suffixes has been used : u within the uranium rod ; s within the metal sheath ; c coolant ; m within the moderator ; 1, 2 fuel element and moderator surfaces.



T_c—Coolant. T_s—Sheath. T_m—Moderator. T_u—Uranium. v—Velocity.

Fig. 1—Temperature components

Uranium

$$\rho_u c_u\frac{\partial T_u}{\partial t}=k_u\nabla^2T_u+H_u \quad . \quad . \quad . \quad (20)$$

Sheath

$$\rho_s c_s\frac{\partial T_s}{\partial t}=k_s\nabla^2T_s \quad . \quad . \quad . \quad . \quad . \quad (21)$$

Coolant

$$\rho_c c_c S_c\left(\frac{\partial T_c}{\partial t}+v\frac{\partial T_c}{\partial z}\right)=P_1h_1(T_1-T_c)+P_2h_2(T_2-T_c)+k_c\frac{\partial^2T_c}{\partial z^2} \quad . \quad . \quad (22)$$

Moderator

$$\rho_m c_m\frac{\partial T_m}{\partial t}=k_m\nabla^2T_m+H_m \quad . \quad . \quad (23)$$

The following boundary conditions apply :

$$T_u=T_s \text{ at } r=r_0, \text{ all } z$$

$$-k_u\left(\frac{\partial T_u}{\partial r}\right)_{r=r_0}=-k_s\left(\frac{\partial T_s}{\partial r}\right)_{r=r_0}, \text{ all } z$$

$$-k_s\left(\frac{\partial T_s}{\partial r}\right)_{r=r_1}=h_1(T_1-T_c), \text{ all } z$$

$$k_m\left(\frac{\partial T_m}{\partial r}\right)_{r=r_2}=h_2(T_2-T_c), \text{ all } z$$

Boundary conditions at $z=z_0$ and $z=z_0+L$ giving heat loss from the rod, sheath, and moderator ends, depend on the system.

In the heat-balance equation for the coolant, T_c represents the fluid bulk temperature and, since radial conduction of heat has been neglected, it is implied that all fluid in any radial plane has constant temperature, at the bulk value.

Clearly, equations (20) to (23) are not convenient for use in reactor dynamic analyses, and some attempt at simplifying them is worth while. It is proposed that equations (20) to (23) should be rewritten as

$$(\alpha_1\rho_u c_u S_u+\alpha_2\rho_s c_s S_s)\frac{\partial T_1}{\partial t}=S_uH_u-P_1h_1(T_1-T_c) \quad . \quad . \quad . \quad . \quad . \quad (24)$$

$$\rho_c c_c S_c\left(\frac{\partial T_c}{\partial t}+v\frac{\partial T_c}{\partial z}\right)=P_1h_1(T_1-T_c)+P_2h_2(T_2-T_c) \quad . \quad . \quad . \quad . \quad . \quad (25)$$

$$\alpha_3\rho_m c_m S_m\frac{\partial T_2}{\partial t}=S_mH_m-P_2h_2(T_2-T_c) \quad . \quad . \quad . \quad . \quad . \quad (26)$$

Equation (24) suggests that the heat capacities of the uranium and sheath can be lumped together, assuming that a unit change in the fuel-element surface temperature corresponds to changes of α_1 and α_2 in the uranium and sheath-metal temperatures respectively. Similarly equation (26) suggests that for a unit change in the moderator surface temperature the moderator mean temperature changes by α_3 units. α_1, α_2, α_3 will generally be obtained from a study of the initial and final steady-state values of the relevant temperatures. The modified equations also imply that axial conduction can be neglected, and therefore that convective heat-transfer predominates.

Equations (24), (25), and (26) are applicable at any position in the reactor channel, and they will be modified further to represent the mean temperatures in a finite length or stage of the channel in the following way. The axial mean temperature in a stage will be defined as

$$\bar{T}_r=\frac{n}{L}\int_{z_{r-1}}^{z_r}Tdz$$

where the whole channel length is assumed to be divided up into n stages, and the expression is written down for the r stage.

It will be further assumed that n is large enough to make the approximation that in any stage

$$T_{cr}-T_{cr-1}=2(\bar{T}_{cr}-T_{cr-1}) \quad . \quad . \quad (27)$$

It can be shown that equation (27) applies in the steady state.

With these definitions, equations (24), (25), and (26) can be written as

$$(\alpha_1\rho_u c_u S_u+\alpha_2\rho_s c_s S_s)\frac{d\bar{T}_{1r}}{dt}=\frac{nS_u}{L}\int_{z(r-1)}^{z_r}H_u dz-P_1h_1(\bar{T}_{1r}-\bar{T}_{cr}) \quad . \quad (28)$$

$$\rho_c c_c S_c\left[\frac{d\bar{T}_{cr}}{dt}+\frac{2nv}{L}(T_{cr}-T_{cr-1})\right]=P_1h_1(\bar{T}_{1r}-\bar{T}_{cr})+P_2h_2(\bar{T}_{2r}-\bar{T}_{cr}) \quad . \quad (29)$$

$$\alpha_3\rho_m c_m S_m\frac{d\bar{T}_{2r}}{dt}=\frac{nS_m}{L}\int_{z(r-1)}^{z_r}H_m dz-P_2h_2(\bar{T}_{2r}-\bar{T}_{cr}) \quad . \quad . \quad . \quad . \quad . \quad (30)$$

Clearly, for T_{cr-1} in equation (29) from equation (27) can be written

$$T_{cr-1}=2\bar{T}_{cr-1}-2\bar{T}_{cr-2}+2\bar{T}_{cr-3}\ldots\pm T_{c1}$$

Equations (28), (29), and (30) will of course be repeated n times, corresponding to the n axial stages of the channel, and there

will be $(n-1)$ equations of the above type connecting the inlet coolant temperature to each stage to the previous stage mean coolant temperatures.

Where one stage only is required, that is, it can be assumed $T_{c\,out}-T_{ci}=2\overline{T}_c-T_{ci}$, the equations reduce to the three simple equations

$$(\alpha_1\rho_u c_u S_u+\alpha_2\rho_s c_s S_s)\frac{d\overline{T}_1}{dt}=\frac{S_u}{l}\int_{z_0}^{z_0+L}H_u dz-P_1h_1(\overline{T}_1-\overline{T}_c) \quad (31)$$

$$\rho_c c_c S_c\left[\frac{d\overline{T}_c}{dt}+\frac{2v}{l}(\overline{T}_c-T_{ci})\right]=P_1h_1(\overline{T}_1-\overline{T}_c)+P_2h_2(\overline{T}_2-\overline{T}_c) \quad (32)$$

$$\alpha_3\rho_m c_m S_m\frac{d\overline{T}_2}{dt}=\frac{S_m}{L}\int_{z_0}^{z_0+L}H_m dz-P_2h_2(\overline{T}_2-\overline{T}_c) \quad (33)$$

Ultimately, in such an analysis, the reactivity changes must be tied to component temperature changes, and the number of axial stages required to give satisfactory answers will be a function of the rapidity of the temperature changes. In general, if the relaxation times associated with coolant temperature changes is long compared with the time spent by an element of coolant in the core then the number of axial stages required is small. For example, most of the analyses carried out on gas-cooled graphite-moderated reactors have been done quite satisfactorily with a single stage, but it is likely that analyses of the kinetics of circulating fuel reactors would call for four to six stages.

In the form so far established the thermodynamic equations contain integrals of heat generation rate, which would be given by a rigorous solution of the neutron kinetic equations. If it be assumed that the flux distribution remains constant during transients, then the neutron kinetic equations can be simplified considerably, as already shown, by the use of mean values. The integrals in equations (27) to (30) or (31) to (33) then require calculation once only. It is then permissible to write

$$\frac{S_u}{l}\int_{z_0}^{z_0+L}H_u dz=\epsilon_1 P$$

and

$$\frac{S_m}{L}\int_{z_0}^{z_0+L}H_m dz=\epsilon_2 P$$

where P is the total heat output and ϵ_1, ϵ_2 are constants which can be determined from the known axial and radial flux distributions in the reactor. It would be most appropriate in these cases to take the thermal equations (31) to (33) as applicable to the most highly rated channel, where the maximum temperatures in the core would occur.

We shall now write equations (31) to (33) as

$$(\alpha_1\rho_u c_u S_u+\alpha_2\rho_s c_s S_s)\frac{d\overline{T}_1}{dt}=\epsilon_1 P-P_1h_1(\overline{T}_1-\overline{T}_c) \quad (34)$$

$$\rho_c c_c S_c\left[\frac{d\overline{T}_c}{dt}+\frac{2v}{L}(\overline{T}_c-T_{ci})\right]=P_1h_1(\overline{T}_1-\overline{T}_c)+P_2h_2(\overline{T}_2-\overline{T}_c) \quad (35)$$

$$\alpha_3\rho_m c_m S_m\frac{d\overline{T}_m}{dt}=\epsilon_2 P-P_2h_2(\overline{T}_2-\overline{T}_c) \quad (36)$$

It is essential to examine how the channel component temperatures can be expected to vary in a transient, and solutions to the above equations are easily obtained in cases where the time variation of P can be simply represented in algebraic form.

Thermodynamic Responses

A system will be considered to which equations (34) to (36) are applicable. The simplest case amenable to an analytical solution is that of a step in reactor power output, and this problem was first examined by Woodrow.‖ Equations (34) to (36) will be written as

$$\frac{dT_1}{dt}=aP-b(T_1-T_c) \quad (37)$$

$$\frac{dT_c}{dt}+\frac{2u}{L}(T_c-T_{ci})=c(T_1-T_c)+d(T_2-T_{ci}) \quad (38)$$

$$\frac{dT_2}{dt}=eP-f(T_2-T_c) \quad (39)$$

where

$$a=\frac{\epsilon_1}{\alpha_1\rho_u c_u S_u+\alpha_2\rho_s c_s S_s}$$

$$b=\frac{P_1h_1}{\alpha_1\rho_u c_u S_u+\alpha_2\rho_s c_s S_s}$$

$$c=P_1h_1/\rho_c c_c S_c$$

$$d=P_2h_2/\rho_c c_c S_c$$

$$e=\epsilon_2/\alpha_3\rho_m c_m S_m$$

$$f=P_2h_2/\alpha_3\rho_m c_m S_m$$

Consider a case in which a step in heat production rate occurs from P_0 to P_0+P' so that during the subsequent temperature transients the temperatures are T_0+T_c', with the respective suffixes 1 and 2, and assume that during the temperature transients the coolant inlet temperature T_{ci} to the system remains constant at zero, so that all component temperatures are measured above this datum level.

In the steady state :

$$T_c=\frac{acf+bdc}{bf\,2u/L}P \quad (40)$$

$$T_2=\frac{e}{f}+\frac{acf+bdL}{bf\,2u/L}P \quad (41)$$

$$T_1=\frac{a}{b}+\frac{acf+bdL}{bf\,2u/L}P \quad (42)$$

which are the particular integrals for equations (37) to (39). The complementary functions are given by

$$\overline{T}_1'=D_1e^{\lambda t},\ \overline{T}_c'=D_ce^{\lambda t},\ T_2'=D_2e^{\lambda t} \quad (43)$$

where λ is given by

$$\lambda^3+\left(\frac{2u}{L}+b+c+d+f\right)\lambda^2+\left[f\left(\frac{2u}{L}+c\right)+b\left(\frac{2u}{L}+d+f\right)\right]\lambda+bf\frac{2u}{L}=0 \quad (44)$$

and the coefficients in equation (43) are related by

$$D_1=\frac{b}{\lambda+b}D_c,\ D_2=\frac{f}{\lambda+f}D_c \quad (45)$$

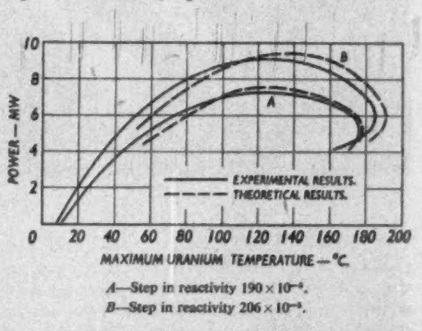
Total Response

The total response of the system will be given by the combination of the neutron kinetic equations (5) to (6), the thermodynamic equations (37) to (39), and the reactivity equation (19). One of these equations is clearly non-linear and solutions in particular cases are normally obtained by numerical integration or by electronic analogue techniques.

It has been pointed out that safety kinetic investigations can normally be reduced to cases arising from rapid reactivity changes, coolant flow changes, or temperature changes caused by influences external to the reactors—that is, heat exchanger transients—and such problems can be analysed by the use of these equations. In cases of reactivity differences the forcing function will be the term $f(t)$ in equation (19), and this may be of any form, a step increase in reactivity, a ramp function, or a sinusoidal function. In coolant flow changes the forcing functions will be changes in the coolant velocity v and the heat-transfer coefficients in the coolant equation (38). The latter may be of the form $Av^{0.8}$ with gas or water cooling, or $A+Bv^{0.8}$ in the case of liquid metal cooling. Problems arising from heat-exchanger transients can be analysed by a determination of the time dependence of the coolant inlet temperature T_{ci}, which becomes the forcing function. In cases where the reactor transients are rapid it will be possible to separate the heat-exchanger analysis from the reactor analysis, but when long-term changes are required, as in a "start-up," it will be necessary to combine both problems, feeding back into the heat exchanger the time-dependent coolant outlet temperature from the core.

Comparison of Theory and Experiment

It is possible to give a comparison of theoretical results and experimental measurements in the case of BEPO. The results are given in some detail by Wordsworth,¶ and the relevant diagrams are reproduced in Fig. 2, in which is plotted the variation of reactor power against maximum uranium temperature, for two cases. The maximum variation between theory and experiment was about 10 per cent at peak power and 6 per cent at maximum uranium temperature, which, considering the known approximations in the theory and the necessary errors in measuring techniques, is a very fair agreement. It may be said that BEPO, having slow thermal responses, is a favourable case for comparison, and that reactors having more rapid responses could give larger divergence between theory and experiment. It appears from the results already obtained that there is a good theoretical foundation to base studies on, and no doubt experimental results obtained on new systems now operating will give a lead to improvements in the analysis.



A—Step in reactivity 190×10^{-4}.
B—Step in reactivity 206×10^{-4}.

Fig. 2—Comparison of experimental and theoretical transients in BEPO

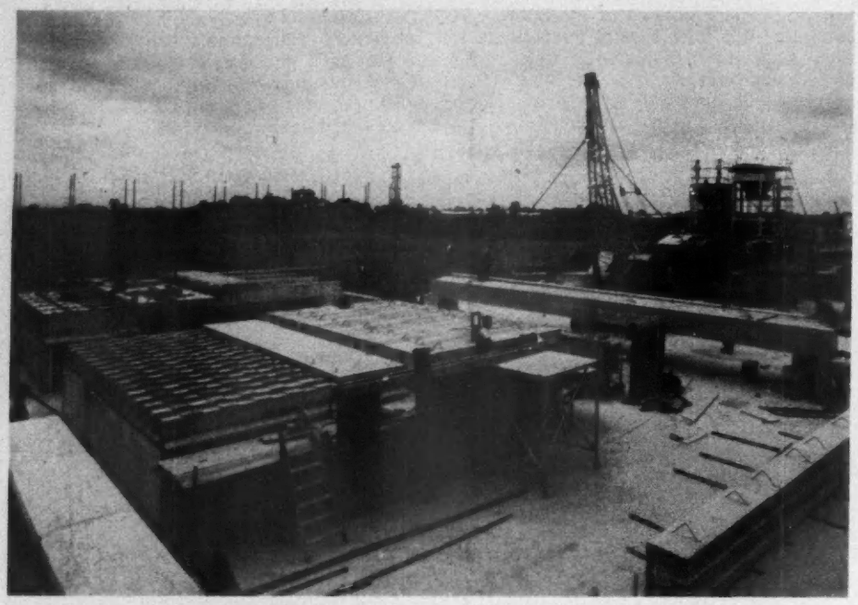
‖ Woodrow, J., A.E.R.E. E/R. 142, Unpublished, "Thermal Time Lag in Air-Cooled Pile": A.E.R.E. E/R 388, "Temperature of Air-Cooled Pile in Initial Stages of Divergence."

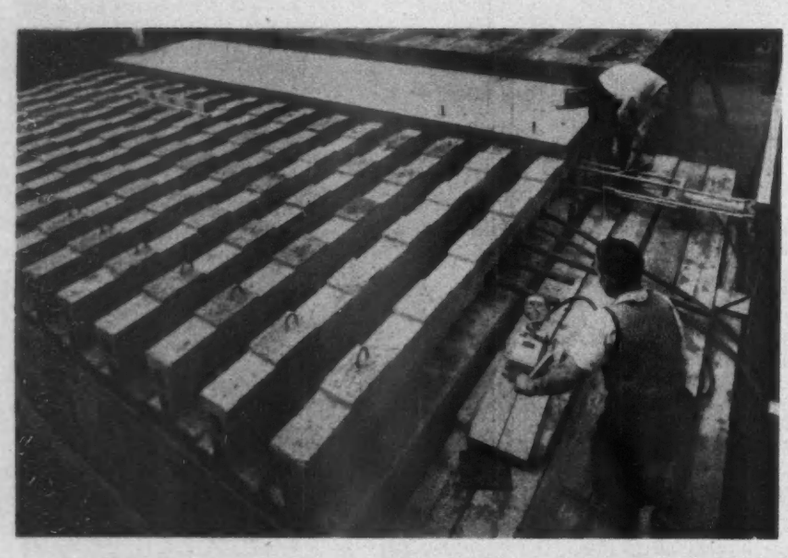
¶ Wordsworth, D. V. A.E.R.E. E/R. 1245, Unclassified, "An Analysis of Power, Temperature and Reactivity Transients in BEPO."

Erection Study of Prestressed Bridges

The main demonstration area of the bridge erection trials recently carried out by Concrete, Ltd., at Hounslow, Middlesex, is illustrated on the RIGHT. The trials concern the main structures of several precast prestressed designs of bridges (and one cast-in-situ post tensioned beam) principally in the range of spans up to 75ft, but also in the range from 75ft to 125ft. Various erection procedures are being compared, and the whole operation involves method and work study, including time study, and costing of all the various procedures needed at the erection site.

In the background, a hollow box beam weighing 10 tons and with a length of 54ft and a width of 2ft, is being lowered into position. This trial involves placing five such beams in position on rubber bearings, and lining-up the cross-stressing holes.





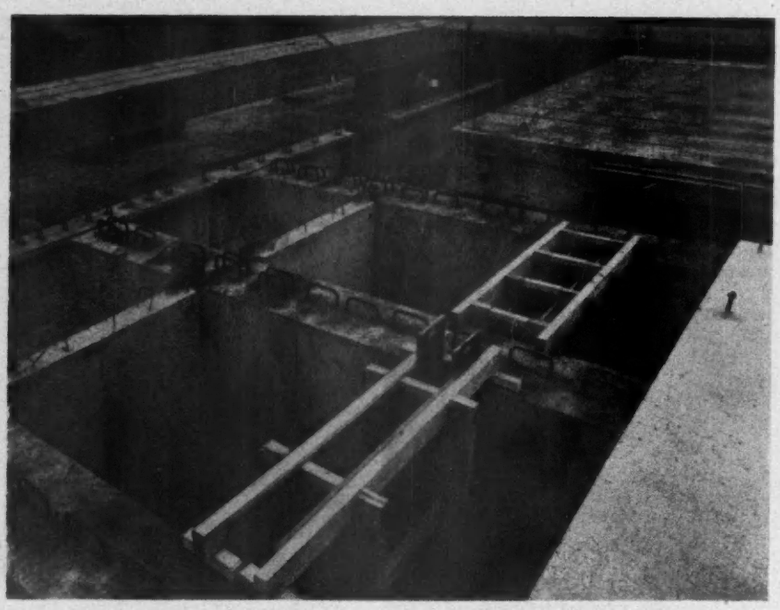
A composite demonstration is shown on the LEFT of various processes on a bridge 16ft long and 24ft wide, consisting of inverted T-section precast, pretensioned beams 18in wide, filled solid with in-situ concrete ; this bridge is also shown in the foreground of the first illustration. Study includes : threading mild steel transverse reinforcement (in foreground) ; threading and, later, withdrawing duct formers ; threading transversely 4/0·276in diameter Magnel cables ; and stressing the cables.

To the left of this bridge in the UPPER view is another bridge of inverted T-beams, but in this case an in-situ deck is cast upon the beams and upon diaphragms placed between them, to give a hollow construction. The T-beams in this second case are 36in wide, the test size of bridge being the same as in the previous case.

A beam and slab bridge, consisting of box beams 14in wide and 72in deep, and spaced at 6ft centres, is shown in the LOWER view, with the slab constructed only on the right. Precast and cast-in-situ diaphragms are compared. Other studies involve placing permanent precast soffit shutters, placing and removing timber soffit shutters, and threading and stressing Lee-McCall bars in the transverse direction.

The illustration on the RIGHT also shows, in the right background, a bridge, again of 16ft length and 24ft wide in the test size, consisting of hollow box beams, placed side by side and stressed together. Each beam is 24in wide, and the depth of the beam may be varied ; in this case it is 30in. Studies include threading and withdrawing the duct formers for transverse stressing, and threading and stressing 4/0·276in diameter P.S.C. cables. Design includes a mechanical key for shear between beams. Tests are to be carried out on a one-third scale model of one of these bridges with a new 100-ton rig. The degree of cross-stressing needed for the bridge to behave as a slab, rather than as a number of separate beams, will then be ascertained ; as a slab bridge, the design is especially advantageous.

Other trials in the series are : post-tensioning a 54ft I-beam (background—LOWER view), 15in wide and 50in deep, by Lee-McCall and Freyssinet equipment, including study of threading the cables and stressing, and assembling the shuttering, reinforcement and ducts. A jointing exercise, in which joints between segments of a hollow box beam 24in wide and 30in deep, with three cable ducts, are made respectively with neat cement grout, ½in wide ; dry mortar, 1in wide, and vibrated concrete, 4in wide (right of TOP view). And a grouting exercise for 30ft lengths of 1¼in diameter Lee-McCall bar in sheath ; 12/0·276in diameter Freyssinet cable in sheath ; 4/0·276in diameter P.S.C. cable in square sheath ; and 8/0·276in diameter Gifford-Udall-CCL cable in sheath.



Extensions at Derby's Sewage Treatment Works

No. I

A major reconstruction scheme for the sewage disposal works serving the county borough of Derby has been inaugurated. The scheme involves pumping stations and mains, and at the works itself a vast installation of biological filters. Provision for recirculation and alternating double filtration in these filters has involved the installation of low-lift pumps, which, although forming only a small pcrt of the whole scheme, are interesting, since they are variable-pitch, axial-flow machines with completely automatic control. The scheme is briefly described, but the filter pumps and their control are explained in more detail.

ON July 1, an extensive scheme of reconstruction at the sewage disposal works at Spondon, which serves the county borough of Derby, was inaugurated. Reconstruction has been in progress since 1953, the total value of the scheme being about £2,500,000, and the works is now able to treat a dry-weather flow of 18 m.g.d. This figure is the estimated dry-weather flow for 1971, and includes 6 m.g.d. of trade waste from the neighbouring factory of British Celanese, Ltd.; the present dry-weather flow is over 9 m.g.d. through the borough's normal main sewers plus the 6 m.g.d. from the factory. New and old elements of the Spondon works are shown in the aerial view ; secondary treatment is by biological filtration, and the new filter beds have been an important part of the reconstruction scheme.

The new works are as follows :—A pumping station for lifting sewage from the main sewers to the works ; reconstruction of the sedimentation tanks ; three new batteries of filters for secondary treatment, each with a low-lift pumping station and humus tanks ; and sludge digestion plant, which is still under construction.

The works were undertaken by the county borough of Derby. The consulting engineers are Messrs. J. D. and D. M. Watson, and the main civil engineering contractor is Holloway Brothers (London), Ltd. The contractor for the sludge digestion plant and some other site works is Hussey, Egan and Pickmere, Ltd. British Celanese, Ltd., is a substantial contributor towards the cost of the Spondon works, and has also constructed a new pumping station and rising main and carried out other works at its factory. The consulting engineers for British Celanese are Messrs. John Taylor and Sons.

Main Pumping Station

The new pumping station was built within a cofferdam 110ft by 100ft in size and sunk to a depth of 30ft. The borough's sewage is brought to it under the river through an inverted syphon consisting of twin 42in diameter concrete pipes. Grit channels and comminutors are installed here. This is done before the sewage is pumped.

The grit channels are believed to be the first of their kind built in this country, and are illustrated herewith. Each one comprises a rectangular channel, with a compressed air pipe with diffusers running along one of the sides ; there are grit hoppers below this pipe. Sewage is introduced at right angles to the direction of the channel at its upstream end. As it reaches the opposite wall, it is induced to flow upwards by the bubbles of diffused air, and thus a spiral flow is started, and maintained down the length of the channel by the air bubbles until the sewage discharges over a weir at the downstream end. Since the effective length over which settlement occurs approximates to the path of the spiral flow, the length of channel needed is much reduced compared with the more conventional constant-velocity channels.

In the pumping station itself, there are five vertical-shaft centrifugal pump sets, each with a pumping capacity of 20 m.g.d. Two of the sets handle dry-weather flow, two are for storm-water, and one is a standby for either duty. The two storm-water pumps are powered by diesel engines of 300 b.h.p., the other three by dual-fuel engines of 256 b.h.p. This machinery was supplied by the National Gas and Oil Engine Company, Ltd., with W. H. Allen, Sons and Co., Ltd., as sub-contractors for the pumps.

The speed of the engines is automatically governed from the sump level. Heat in the engine cooling water will be recovered for heating the sludge in the new digestion plant and for space heating in the pumping station. An installation of this kind was described in THE ENGINEER of June 13. There is space for another pump in the station, and there is also an installation of three rotary air blowers for the grit channels. Effluent can be recirculated to the main sump at low flows, and sludge from the humus tanks is returned to the main

Spondon works. On the right and across the centre background is the River Derwent. Next to the river, on the right, is the new pumping station, with sludge digestion plant under construction in front of it. To the left of it are seven storm-water tanks, and left again, primary sedimentation tanks, all part of the old works. The circular filters have now been replaced by the three batteries of filters, each with eight filters, four humus tanks and a pumping station

flow, and repumped to the primary tanks. The pumping station was completed last year.

Treatment of Trade Effluent

The primary sedimentation tanks, through which the sewage passes from the main pumping station, have been extensively reconstructed and improved. The 6 m.g.d. of trade waste from the British Celanese factory is introduced into the main flow of sewage after the latter has passed through the sedimentation tanks. A pumping station with an output of 4·3 to 8·1 m.g.d., and a 27in rising main serving the factory were also completed last year.

This factory is shown in the background of our first illustration. Its use of water can reach 60 m.g.d., most of it for cooling. To improve conditions in the river, 14 m.g.d. of cooling water is now recirculated through two coolers. The trade waste itself, however, has been reduced in bulk as much as possible—e.g. by re-using dirty water and keeping cooling water out of the effluent drains—and by certain changes in production, principal amongst which was the elimination from the trade effluent of "black liquor" from the kiering of cotton. This measure alone (the black liquor is now evaporated and burned) reduced the polluting effect by 20 per cent. From this stage, extensive experiments were carried out to find the best method of treating the effluent, the result being that it is mixed with the domestic sewage and purified by biological filtration.

Biological Filters

The three batteries of biological filters account for over half of the cost of the reconstruction scheme. Two of the batteries are entirely new, and one is reconstructed. Each one comprises a rectangular block of eight filter beds, one bed being 425ft long by 54ft wide. The total filter area is nearly 13 acres, and the depth of filter medium is 6ft, the medium being granite chippings, of 2½in size in the lower 2ft and 1½in size above.

Each battery has culverts, penstocks and a low-lift pumping station, and four humus tanks, each 85ft in diameter and 8ft deep at the side wall. Operation by single filtration, recirculation, or alternating double filtration is thus feasible. At present alternating double filtration is being used. The travelling distributors on the filters are cable hauled and there are ninety-two of them in the three batteries.

In constructing these filters, a particularly comprehensive conveyor system was used to handle the granite aggregate, of which there is a total of 120,000 cubic yards. Travelling conveyor bridges were installed over the filters, each with a cantilevered final conveyor which could be moved vertically and horizontally to place the aggregate just where it was needed; the capacity of one of these installations with its associated loading machine and loading conveyors was 30 to 35 cubic yards per hour.

Owing to the abrasive nature of the granite, great difficulty was experienced in maintaining output by the loaders and there were repeated breakdowns. This was particularly so in the case of the 1½in size when an output of 400–500 tons per day was required. Experiments were carried out which showed that direct loading from tipping lorries into a Johnson "Lo-Band" loader minimised wear. The loader is a large mobile hopper into which a lorry can tip its load and through which a 24in wide conveyor belt moves the material to a discharge height of 4ft 6in into the articulated conveyors. The machine is driven by a 4 h.p. electric motor and is geared to meet a peak load of 80 cubic yards per hour. Although the time lost due to breakdown of plant was not entirely eliminated, it was reduced to reasonable limits. In modifying the existing filter block some 34,000 cubic yards of granite were reclaimed, together with the filter tiles.

Axial-Flow Filter Pumps

Although the Kaplan turbine is a well-established machine, universally used where hydraulic conditions are appropriate, the corresponding device for pumping, viz., an axial-flow pump with adjustable blades, is comparatively rare. The filter pumps at Spondon are examples of this class of pumps; they are, furthermore, noteworthy for the incorporation of completely automatic operation in which floats in the sumps operate control mechanisms which feather their blades.

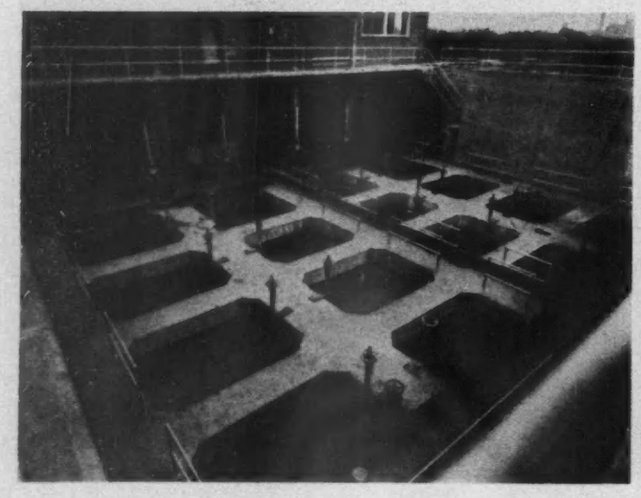
It will be clear that whenever either recirculation or alternating double filtration are called for, the partially treated sewage must be pumped back to the inlet channels of the filters. These channels are of limited capacity, and sudden variations in the level of the sewage in them are undesirable, since uneven dosing of the filters must be avoided. So the flow discharged by the pumps must vary steadily with the sewage flow.

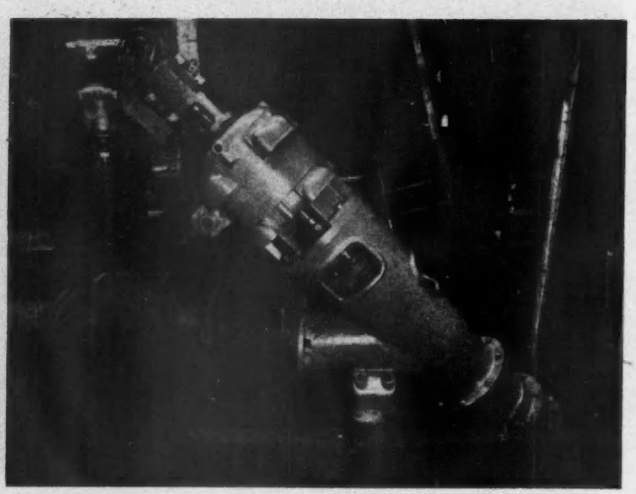
Two methods for handling such a variable duty were considered: (*a*) by variable-speed constant-pitch axial-flow pumps and (*b*) constant-speed variable-pitch axial-flow pumps. Economic analysis of both methods indicated that constant-speed variable-pitch pumps offered a greater and more flexible range of efficient pumping. Constant-speed squirrel-cage induction motors, arranged for direct-on starting, to drive the pumps, were a more attractive proposition than the more complicated electrical system associated with the variable speed installation. Variable-pitch axial-flow pumps enabled a flow variation between 25 and 125 per cent of designed capacity to be handled at constant speed, and by virture of the nature of their head/discharge characteristics, the pumps could operate in parallel at different pitch settings without adversely affecting the efficiency of working to any appreciable extent.

The filter pumps at Spondon are grouped in three independent pumping stations, one station serving each battery of filters. There are three pumps in each of these stations. Vickers-Armstrongs (Engineers), Ltd., was awarded a contract for the nine 12in diameter pumps required. Each pump was designed to have maximum pump efficiency when handling 3700 g.p.m. at a total head of 15·5ft. It was required that the pumps should be completely automatic in operation, each pumping station responding to the variation in flow of the effluent reaching the respective suction sumps.

A variable-pitch pump, where pitch variation is required whilst the unit is running, incorporates a hand-operated or electro-servo-motor operated mechanism mounted on the non-driving end of the main pump motor. The main pump motor and pump shaft has a hole bored centrally to accommodate an operating rod connecting the pitch changing mechanism with the impeller assembly. Axial movement of this rod via the impeller assembly mechanism gives rotary motion to the impeller blades, setting the blades at any required pitch.

The accompanying drawing shows the mechanical arrangement of the pump impeller. The square cam block is threaded and moves axially when the actuating rod is turned. There is an inclined groove in each face of the cam block, and a cam follower attached to the corresponding blade root engages in each of these grooves. Thus axial movement of the cam block alters the pitch of the blades. The trailing edges of





(Left)—Four spiral-flow grit channels. Sewage flows into the channels from an inlet in the foreground; in the background are four comminutors and the pumping station. Note the air mains serving the channels. (Right)—Axial-flow pump on test at maker's works. Note, upper left, the servo-motor unit which controls the actuating rod

the blades fit into recesses in the outer surface of the boss when at maximum pitch.

Each blade root is cylindrical and has an O-ring seal. It is held in the boss by a back plate. The hub is oil-lubricated, and it and the hollow shaft are filled with oil at a slightly higher pressure than the pump head ; there is an oil seal at the top of the actuating rod. The boss is machined all over ; the impeller blades are ground and polished. The pump ring is machined to a spherical shape, so that the tip clearance of the blades is constant at all pitch angles.

Automatic Control of Pumps

The particular electrical control system required was developed jointly by Vickers-Armstrongs (Engineers), Ltd., and Crompton Parkinson, Ltd., after consultation with Messrs. J. D. and D. M. Watson, and provides a new technique in the control of a continuously varying suction sump level. The system has been designed to recognise automatically a change in level of the effluent in the suction sump and thence vary the pitch of the impeller blades to increase or decrease the pumping capacity. It is in effect a servo-system, actuated by floats which follow the changes in effluent level, and comprises two potentiometers, polarised relays, reversing contactor and a motor with integral reduction unit, for each pump.

The first potentiometer is mechanically coupled to the float linkage and connected electrically to a polarised relay. When a signal from the potentiometer overcomes the standing bias, the relay operates and actuates a reversing contactor which in turn controls the direction of rotation of a ½ h.p. servo-motor. This motor and the associated gear unit are mounted integrally on the non-driving end plate of the main pump motor. The gear train is coupled, in turn, to the actuating rod which passes through the hollow shaft of the main motor, to the impeller mechanism.

A second potentiometer, mechanically coupled to the actuating rod, is connected to the polarised relay so that when the change in pitch reaches a position corresponding to the float position, the polarised relay is de-energised and the servo-motor stops driving. As long as the signals from the potentiometers are equal, there is no signal to operate the relay and the pitch—and therefore the rate of pumping—remains unchanged.

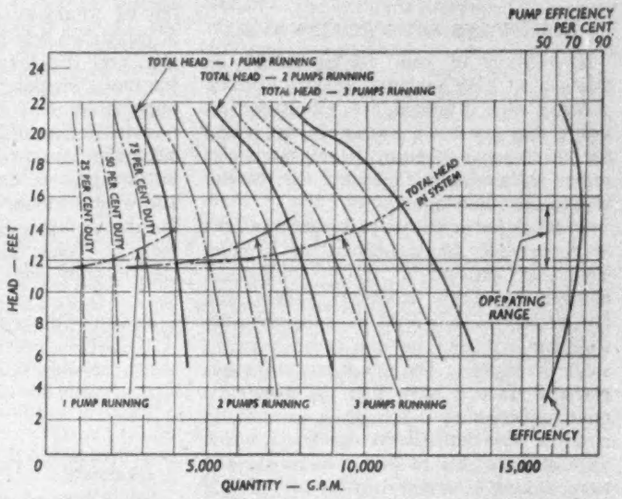
This form of automatic control is obviously ideal where the rate of flow changes irregularly and, to provide a wide but economical range of control, the three pumps in each station are switched independently.

The level at which the pumps operate is staggered so that one, two or three pumps automatically start up as the level of effluent rises. The conventional " No Flote " system of control starts or stops the individual motors, and to ensure a uniform rate of time in service the control connections to the motors are made interchangeable. Other features of the system are that additional electrodes operate high and low level over-riding controls, the former causing the mode of operation to change to single filtration, and stopping the inflow to the station (in conjunction with an audible alarm) and the latter stopping all the pumps. Also the three pumps cannot be started simultaneously and thus overload the supply network.

The main motors include such features as a hollow shaft to accommodate the actuating rod and mountings for the pitch control mechanism. These motors develop 25 h.p. at 1460 r.p.m. and operate at 415V a.c., 3-phase, 50 c/s.

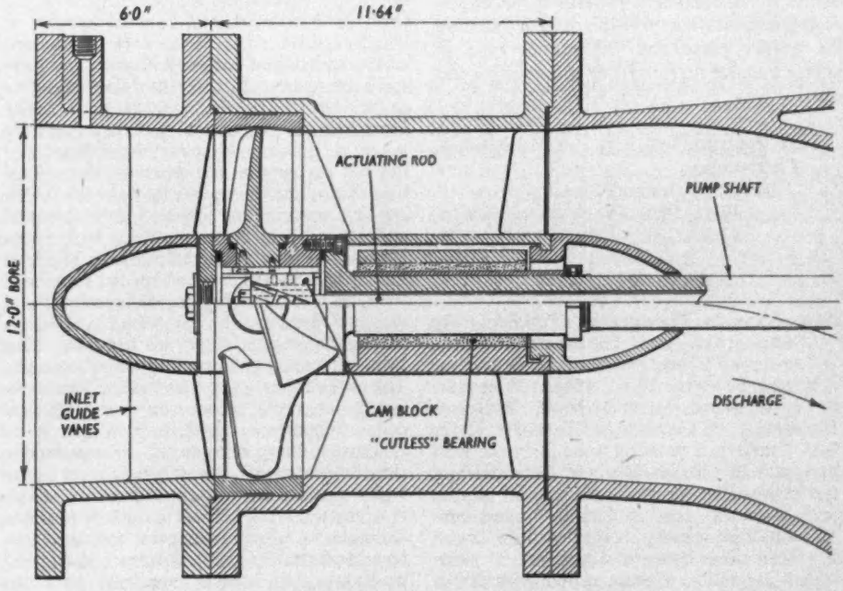
Sequence of Control Operations

Summarising the sequence of operations in controlling the pumped output, we have at each sump five electrodes and three floats, viz., one electrode at the minimum and one at the maximum level, three control electrodes and one float associated with pitch control when one, two and three pumps respectively are in operation. As the effluent in the sump rises, the electrode controlling No. 1 pump starts up the set, with the pump working at minimum pitch. If the effluent level in the sump continues to rise, the float for this set, via the pitch control motor on the main motor end shield, changes the pump impeller pitch, increasing the pump output until the water level ceases to rise any further. If, however, one pump is not sufficient to handle the increasing rate of flow, the second electrode, set at a predetermined higher level, starts up the second pump. The impeller pitch of the first set is then automatically reduced by the action of its associated float gear so that both pumps work with equal duty. Thereafter any further rise in level is sensed by the second float which increases the pitch of the impellers of both pumps until both eventually attain their fully-coarse pitch setting. If two pumps are not then sufficient a third electrode, set again at a predetermined higher level than the first two electrodes, brings into action the third pump and a similar sequence occurs. If three pumps are unable to prevent further rise in the sump level when all are pumping at maximum pitch an over-riding electrode, set at maximum permissible sump level, causes the change in mode of operation to simple filtration by means of a power-operated turnstile penstock. A reverse sequence takes place when the rate of flow decreases. Performance curves for the three pumps, and a pump on test at the maker's works, are shown in the illustrations.



Performance of pumps when running at a constant speed of 1450 r.p.m.

(To be continued)



Section through impeller of variable-pitch axial-flow pump

Technical Report

The Prediction and Measurement of Temperatures in Concrete Structures with Particular Reference to Some Recent Construction in Frozen Ground. By J. D. Geddes, Ph.D., A.M.I.C.E. Bulletin No. 11. Department of Civil Engineering, King's College, University of Durham, Newcastle upon Tyne. Price 2s. 6d.—This bulletin contains a paper presented at a meeting of the Northern Counties Association of the Institution of Civil Engineers in Newcastle in December, 1956. The discussion at the meeting is not given.

The effects of temperature upon concrete are discussed under four headings, namely : (i) the influence of temperature on the development of strength ; (ii) the disruptive effect of low temperatures upon green and mature concretes ; (iii) deterioration at very high temperatures ; (iv) harmful stresses caused by temperature gradients or restrained shrinkage or expansion. Heat transfer in concrete is discussed in some detail and equations are deduced, analysing the various methods of transfer, and the internal generation of heat.

The last part of the paper describes an investigation of temperature variation in a reinforced concrete shaft lining constructed against frozen ground, when the freezing process was used to sink a certain section of a new shaft of the Hawthorn project, Murton-Eppleton colliery in County Durham.

LETTERS AND LITERATURE

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

RAILWAYS INTO ROADWAYS

SIR,—Many of your correspondents on this subject have said that railway electrification is what is needed, not railway conversion ; they say it is a matter of what is best for the national economy, having particular regard to imports of fuel ; but they do not supply facts and figures.

So far as public service passenger transport is concerned, the operations of London Transport provide a ready comparison between a motor transport system and an electric railway system, geographically superimposed one on the other, under a single Executive. The recent bus strike has perhaps made it seem that the pneumatic tyred undertaking is struggling to exist, in contrast with the railways concerned, which were at once able to face a wage rise and have, indeed, been eulogised (by Mr. H. Cox in your issue of May 16) as a pattern for British Railways to copy. But in fact the contrast is strikingly the other way, as is shown by the following table of statistics taken mainly from B.T.C's 1957 Report, using the commonly accepted fuel equivalents of 1 ton oil, 1·7 tons coal, 3000 units of electricity.

	London Transport 1957	
	Road Services	Rail Services
Capital employed, millions ...	£32·7	£104·7
Passenger-miles, millions	7175	3332
Fuel consumed :		
Road diesel oil, million gallons	32·4	Nil
Electricity, million units... ...	177	635
Total coal equivalent, tons ...	305,000	360,000
Coal equivalent per million passenger-miles, tons	42·5	108·5
Net receipts, millions...	£3·8	£1·9
Add : Fuel tax paid, millions	£4·0	Nil
Licence duties, millions	£0·8	Nil
Gross national benefit, millions...	£8·6	£1·9
Deduct: Share of B.T.C's central expenses, millions	£1·5	£4·5
Road wear, say, millions	£1·0	Nil
Net national benefit, millions ...	+£6·1	—£2·6

Viewing that table one is relieved to know that B.R's electrification programme is a modest one—in route mileage if not in capital expense. Of the entire system 5·3 per cent is electric already and electrification is not billed to do much more than double in length by about 1970. Incidentally well before that date the London–Yorkshire motorway should be ready, and there may have to be second thoughts about the electrification of the London–York main line railway : the New York Central Railroad lost 23 per cent of their passenger traffic when the State throughway opened.

However, the main issue raised by your pro-electric correspondents concerned reliance on imported oil. " Remember Suez," they say. That was a tanglesome business and some people's most vivid recollection of it is of an embarrassing glut of motor spirit caused by rationing : possibly it only showed how safely we can rely—and do rely—on a well organised, flexible, world-wide oil industry. Britain's annual fuel requirements are already of the order of 250 million coal equivalent tons. According to a statement by the Minister of Fuel and Power in 1956 they may exceed 300 million tons in 1965. With coal output remaining only a little above the 200 mark, and nuclear power scarcely contributing by that date, we must rely on oil anyway. It is therefore a matter of using each type of fuel to the best advantage, and the long accepted view is that transport, whether by sea, by air or by land, justly holds first claim on oil. The continuous feeding of fuel, even in the form of electricity, into a rapidly moving vehicle can be an expensive, uneconomic process, as the above table shows. B.T.C. seem to concur ; for the modernisation scheme is very much more a " dieselisation " scheme than an electrification one.

T. I. LLOYD

Railway Conversion League, Ltd.,
123/124, Newgate Street,
London, E.C.1,
July 14, 1958.

DESIGN IN ENGINEERING

SIR,—Your editorial and extracts from a paper by Mr. Hugh Clausen on Engineering Design in your issue of June 20 crystallised very clearly the magnitude of our failure to give status to the engineering designer and what the results of that failure may ultimately be in reducing our standard of living in comparison with such countries as Russia, Germany and U.S.A.

Those who have worked in factory drawing and design offices in the past will know the low status and remuneration given to design staff in comparison with sales and administrative staffs resulting in the majority of designers aiming to move to sales or administration at the earliest possible moment.

With the scarcity of designers since the war their position has improved considerably but obviously only under duress.

Not however until management—and the financial " moguls " behind them—realise that the designer is the key to the success of their product, whatever it may be, and is one of the most important persons in an engineering organisation, will the designer achieve his proper place and the proper type of young man be persuaded to enter the profession.

I. R. MCKECHNIE, A.M.I.Mech.E.

12, Kingsland Park,
Cherryvalley,
Belfast, N. Ireland,
July 11, 1958.

Book Reviews

New Ways in Management Training. By CYRIL SOFER and GEOFFREY HUTTON. Tavistock Publications, Ltd., 2, Beaumont Street, London, W.1. 1958. Price 15s.

IN a foreword to this book, Professor Hawthorne, of Cambridge University, states that " there is a pressing need for more men and women able to combine technical and professional skills with managerial ability and capacity for leadership " and the authors have clearly explained how much has been done by careful research to show how it is possible to train people with this in view. The study described in the book before us was carried out during the years 1954 to 1956 by the Tavistock Institute of Human Relations in collaboration with Acton Technical College, with a view to investigating the possibilities of a department of management and production engineering which could service industry and promote co-operation between industry and the college.

The book before us shows how thoroughly the subject was investigated and clearly demonstrates the useful part that may be played by the technical college working in co-operation with industry. The general scope of the work before us can be gathered from the titles of the chapters, these being : Technological Education and Management Studies ; The Needs and Circumstances of Students ; Circumstances and Attitudes of Local Firms ; The Teacher and His Tasks ; The Development of Services to Students ; The Development of Services to Firms ; Increasing the Teacher's Experience and Skill ; Research as an Active Partnership Between Research Team and College ; The Acton Case Study in Review : Findings, Achievements and Research Methods ; Conclusions : Training for Industrial Responsibility.

One of the difficulties to be overcome lay in the fact that the technical college was regarded as being of an inferior calibre to that of the university, and that its teachers were regarded as being content with much lower remuneration, and accordingly were not likely to be of any help to industry, in that a good manager would not be attracted to a post in a technical college. However, by maintaining close contact with engineering works, both large and small, in the district these doubts were allayed, and a spirit of co-operation was developed. In an endeavour to ascertain the best means of improving services both to students and firms, it was found that students who varied so much in age could not be catered for satisfactorily by the formal lectures that normally are the recognised thing, and as a result, group discussions were substituted. In many cases, provided the necessary safeguards were ensured, a large degree of success resulted. At the beginning of the 1955–56 session an important innovation was introduced in the form of a departmental tutorial system, in which each tutor guided the work of teachers, at the same time enabling students to have someone to consult when they would hesitate to go to the departmental head. Many firms had the impression that they might be asked to do something for the college, and did not dream that the desire of the college was to provide them with improved services, but by maintaining close liaison between college and firm better relations were established, and it was found that firms began to seek help. Some firms had special courses of their own for training in management, and in some instances it was found feasible to arrange an interchange of lecturers, thus bringing college and firm into closer relations. The authors justly say that " while representing the attempts between only one technical college department and its consumer firms to grow a living relationship between them, the developments described clearly have wider significance and application," and this is where the book before us is likely to prove valuable to works managers, technical colleges and students who aspire to managerial positions. It became apparent that the research team brought information, some-

times unpopular, and gave advice which was disliked, but it was appreciated that both information and advice were given in an unbiased manner for acceptance or otherwise as seemed desirable.

The Acton case may be regarded as a typical one, showing how a technical college and engineering works can work in close co-operation, to their mutual advantage. By firms releasing staff and students to go to classes at the college they may find that benefit will accrue to both. Teachers acquired a better first-hand understanding of the organisation from which their students were drawn, and so were better able to teach them in the manner that would best suit requirements.

Among the conclusions reached by the authors it may be noted that they are of opinion that unless there is a radical change, technical colleges can only play a limited part in training students to assume managerial rank, and that it is extremely difficult to recruit men with managerial ability for posts in the technical college, for the really good men will secure positions in industry with salaries that are beyond the power of the college to pay. They detected a lack of flexibility, in that technical colleges are administered by local authorities, which are often averse from radical change, and for this very reason the authors maintain that with their greater freedom of action the universities might assume " a more important role in helping to educate men and women to play leading roles in industry."

In summing up the position, it is suggested that there is a real need for management training institutions to be set up with university status, and prepared to " enter into an active partnership with industrial firms in meeting their needs and those of their staff." Certainly the days are long since past when it was boldly affirmed that " managers are born, not made," and management should now be reckoned as a profession for which adequate training is essential. By confining the research described in this book to one college and the works in its vicinity, the Tavistock Institute has been able to treat the whole matter more thoroughly than would otherwise have been possible, while at the same time it may reasonably be affirmed that similar conditions occur generally. Accordingly, a study of this book can be commended to managers, potential managers and technical colleges which have or purpose to have courses in training for management.

The Exterior Ballistics of Rockets. By LEVERETT DAVIS, Jr., JAMES FOLLIN, Jr., LEON BLITZER. D. Van Nostrand Company, Ltd., 358, Kensington High Street, London, W.14. Price 64s.

WITH so many people now engaged in the guided weapon industry and in the consideration of satellite vehicles, a publication with the title of this book appears to be very timely. Unfortunately, it is only concerned with the results of studies carried out during the 1939–45 war and shortly after. Hence, it is limited in its scope to rockets without flight control by movable aerodynamic surfaces or jets. Furthermore, only solid propellant rockets of very short burning times (less than one second) are considered and their dimensions are very modest by modern standards. Such rockets are effectively only one stage beyond the conventional artillery projectiles, but, within these limitations, the book is a valuable contribution.

The authors were all engaged in research at the California Institute of Technology, that famous centre of rocket studies, during the war years, and the present volume is compiled from their experience and the vast number of reports and memoranda prepared in that period. These were originally reduced to a single comprehensive, but classified, text, and this has now been modified where necessary to permit the present open publication, which extends to more than 450 pages. The subject is treated, as it must be, from a theoretical standpoint, but with a definite appreciation of the practical problems. The basic theory is given in clear and unambiguous fashion and the equations of motion during launching and afterwards are derived and solutions worked out for many different cases. Mathematics plays an important part in the analysis, but the authors have managed to keep this within the comprehension of engineers with a normal training in this subject.

The first two chapters are devoted to very helpful definitions of the rocket characteristics and the forces involved ; the next four chapters examine the fin-stabilised rocket in great detail, and the final four chapters are given to the spin-stabilised rocket. The various phases of flight each have chapters in which they are examined from every aspect—for instance, the motion during the propellant burning phase is subjected to the effects of linear and angular thrust misalignment, gravity, yawing and mal-launching, side winds, fin errors and the normal aerodynamic forces. A pleasing feature of the treatment is that examples using typical numerical values of the quantities involved are given to illustrate the theoretical conclusions. In addition, the authors point out the limitations of the theory and indicate whether the effects are important or can be neglected. They back up their remarks with experimental evidence in many cases. There can be no doubt that this volume fulfils the task its authors set out to do. It is well produced, adequately illustrated and indexed, and free from errors. It can be recommended to all who want specialist ballistic knowledge.

Installation de la portance sur un profil muni d'une fente de soufflage au bord de fuite et correction due à l'envergure finie. By R. HIRSCH. Publications Scientifiques et Techniques du Ministère de l'Air, No. N.T.69. Service de Documentation et d'Information Technique de l'Aeronautique, Magasin C.T.O., 2, Avenue de la Porte-d'Issy, Paris (15e). Price : Fr.1000.

THE circulation around an aerofoil " blown " by a jet at its trailing edge, and hence its lift, is uniquely determined by a condition of the rear point equivalent to the Joukowski condition for the classical stationary and non-stationary case. The vortex train formed is governed by an equation analogous to the Wagner equation, and the paper deals with the factors involved in setting up this equation and solving it, applying it to two cases for which the results were checked experimentally. The second part of the book describes the case where the span is finite, which involves the setting-up of the basic expressions and an approximative solution of the steady state problem, since in this case the distribution of the circulation along the span is elliptical. Here again results are compared with experiment and the case of a wing interrupted by a fuselage is considered.

Application de la transformation de Laplace et de la transformation de Hankel à la determination de solutions de l'équation de la chaleur et des équations de Maxwell en coordonnées cylindriques. By HUGUETTE DELAVAULT. Publications Scientifiques et Techniques du Ministère de l'Air, No. N.T.71. Service de Documentation et d'Information Technique de l'Aéronautique, Magasin C.T.O., 2, Avenue de la Porte-d'Issy, Paris (15e). Price : Fr.1500

THE Laplace transformation with two variables allows one to solve easily " boundary value " problems governed by a linear partial differential equation with two or three variables and constant coefficients by replacing it by an algebraic equation or a linear differential equation. A degree of axial symmetry, whether of the data or of the region considered, can impose cylindrical co-ordinates, in which case the classical equations no longer have constant coefficients. It became natural in such cases to replace the Laplace transformation by a Hankel transformation, using cylindrical Bessel functions. The treatise discusses this method as well as that of using a finite Hankel transformation simultaneously with a Laplace transformation. The solutions are applied to three-dimensional problems of the propagation of heat between parallel planes and of electromagnetic waves in a cylinder under general boundary conditions.

Book of Reference

The British Shipbuilding Compendium, 1958. The Shipping World, Ltd., Effingham House, Arundel Street, Strand, London, W.C.2. Price 20s.—This compendium is a buyer's guide to British shipbuilding, marine engineering, repairing, ship and shipyard equipment, and lists the firms engaged in the building and repairing of ships together with the principal sub-contracting firms which supply materials and equipment for incorporation in ships. The book is divided into four parts : section " A " gives the names of shipbuilders of ocean-going ships, coasters and small craft and lists ship repairers and dry-dock owners. Propulsion machinery is the concern of section " B," while section " C " deals with general items of equipment, auxiliary gear and materials and lists the various suppliers of nearly 250 items. The fourth section " D " is devoted to shipyard equipment and at the back of the book is an alphabetical index which is useful in ascertaining the range of products manufactured by a particular firm.

Books Received

Mathematical Foundations of Information Theory. By A. I. Khinchin. Constable and Co., Ltd., 10, Orange Street, London, W.C.2. Price 11s.

Theory of Electrical Machines. By W. S. Wood. Butterworth's Scientific Publications, 4 and 5, Bell Yard, London, W.C.2. Price 50s.

Henry Edward Armstrong. By J. Vargas Eyre. Butterworth's Scientific Publications, 4 and 5, Bell Yard, London, W.C.2. Price 30s.

Concrete Technology. Vol. I. By D. F. Orchard. Contractor's Record, Ltd., Lennox House, Norfolk Street, Strand, London, W.C.2. Price 45s.

The Performance of Metal Cutting Tools. By R. Tourret. Butterworth's Scientific Publications, 4 and 5, Bell Yard, London, W.C.2. Price 50s.

Ship and Boat Builder Annual Review, 1958. John Trundell (Publishers), Ltd., St. Richard's House, Eversholt Street, London, N.W.1. Price 50s.

The Coal Industry of the U.S.S.R. Part 2, 5, Training. National Coal Board, Hobart House, Grosvenor Place, London, S.W.1. Price 3s.

A Guide to Nuclear Energy. By R. F. K. Belchem. Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, London, W.C.2. Price 10s.

Principles of Electronics. By Russell H. Krackhardt. The Ronald Press Company, 15, East Twenty-Sixth Street, New York, 10, U.S.A. Price 7·50 dollars.

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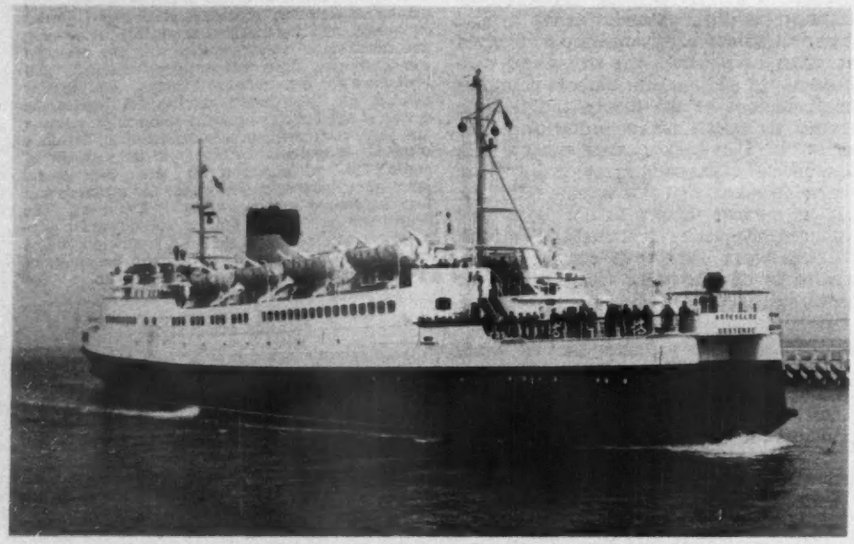
Car Ferry M.V. "Artevelde"

By G. W. TRIPP, O.B.E., F.C.G.I., M.I.C.E.

A second post-war car ferry vessel for the Belgian cross-Channel service has now been completed. Rear-loading ramps give access to two covered decks for vehicles up to the size of large coaches ; in order to allow fuel tanks to remain charged, special fire precautions are taken. Aluminium is extensively used, and forms the deck surfaces. Sulzer diesel engines drive twin screws.

THERE has been such a steady increase in the number of cars, with their drivers and passengers, crossing the Channel that it has been found necessary from time to time to build new vessels for this somewhat specialised work. The increase in the number of cars carried is evidenced by the following particulars : in 1925, 629 cars were carried, while ten years later 4694 were carried, and after the war the figure for 1950 was 15,945, which by last year had risen to 37,953, a large proportion of which had been dealt with in the summer months. In 1936 the Belgian State Administration converted one of their passenger vessels to a car ferry, and it was not long before "London-Istanbul" justified her existence, maintaining regular sailings until the outbreak of hostilities called a halt to the service. When the war was over there was evidence of a further increase in this particular traffic, and it was decided in 1945 to have a vessel specially designed for the work, and to replace the now thirty-six years old "London-Istanbul." Accordingly, an order was placed with the Cockerill Company, of Hoboken, and in September, 1948, "Prinses Josephine-Charlotte" (for a while sailing as "Car Ferry") was launched, and she made her maiden passage on June 3, 1949. Her principal dimensions are : length, overall, 373ft, between perpendiculars, 363ft ; moulded breadth, 49ft ; depth to shelter deck, 28·75ft ; she is equipped with two rudders, that in the bows conforming to the lines of the vessel. The ship is propelled by two Sulzer two-stroke, single-acting, diesel engines, with a total horsepower of 8360 at 320 r.p.m., giving a speed of 22 knots, which is very high for a vessel of this type. She has eight watertight compartments, with three watertight doors operated from the bridge by a hydro-pneumatic system. There is a double door at the end of the car deck, enabling cars to be driven on and off by a mobile ramp at each terminal, whatever the state of the tide. There is ample head room for motor coaches, and the deck has been strengthened to enable lorries, &c., up to a weight of 10 tons to be carried, and about 100 vehicles can be carried. A section of the rear deck was reinforced to enable a number of vehicles which owing to their dimensions could not be accommodated in the garage.

In view of the ever-increasing number of cars to be carried and with the 1958 Brussels World Exhibition in mind, it was decided to have built another car ferry, thereby enabling two sailings in each direction to be made daily. Accordingly, "Artevelde" was launched in February last at the Antwerp shipyards of Messrs. Cockerill. As will be seen by her dimensions, "Artevelde" is rather larger than her sister, her leading dimensions being : length, overall, 382ft 7in ; between perpendiculars, 369ft 7in ; breadth (without fenders), 49ft 2in ; depth from shelter deck, 32ft 11in ; tonnage, 2778 gross ; maximum draught, 12ft 9½in ; corresponding displacement, 3655 tons.



Car Ferry M.V. "Artevelde"

As will be seen from the illustration, "Artevelde" has a pleasing appearance on modern cross-Channel lines, with doors astern to be opened for embarking and landing cars. A novel feature of this ship is that she has two car decks, the upper garage being reached by a ramp from the lower car deck, this ramp being raised when the upper garage is full, to enable more cars to be accommodated on the lower deck ("D"). The ramp between the two car decks lifts up and folds into two parts when the upper garage is full, and both articulated panels stand vertically. The working takes only a few seconds, operation being by hydro-electric gear. In each garage a light turntable 13ft 1½in in diameter facilitates the handling of big cars. As petrol may be left in the cars, in addition to the usual fire-fighting appliances the garages are partitioned by fireproof curtains. The ventilation has been specially considered and means provided to remove the exhaust gases. The headroom is 6ft 10½in and 160 medium-size cars can be carried which is sixty more than on "Prinses Josephine-Charlotte." Provision is also made for the conveyance of extra large coaches up to 11ft 9½in in height. 1000 passengers can be carried, and there are sleeping berths for 124 in the saloons on "E" deck.

The general arrangement is as follows : on the bridge deck is a spacious wheel house equipped with the usual modern aids to navigation, there being two steering wheels for use when sailing astern, each being situated on the outside of the bridge, these operating the bow rudder. Below this is the boat deck ("A") on which there are eight aluminium lifeboats, and it might here be mentioned that aluminium is freely used, the decks being laid in this metal. On this deck also is found accommodation for the ship's officers. Next comes the promenade deck ("B") at the stern of which is a spacious restaurant seating 156 passengers, and towards the bows a large bar with seats for eighty. Outside is ample promenade space, both open and enclosed, for which there is a liberal supply of deck chairs. As already stated, "C" and "D" decks are devoted to the car garages, while on "E" deck are two ladies' and two gentlemen's saloons, while it might be mentioned that there are two de luxe and six special cabins. Such is the general layout of this commodious vessel.

The engine-room is large and well arranged, the twin screws being driven by two two-stroke single-acting Sulzer engines, each having twelve cylinders, with a diameter of 510mm and a stroke of 550mm, and developing 4800 h.p. at 320 r.p.m., giving the vessel a speed of 21 knots. There are twelve fuel pumps, twelve scavenger pumps and twelve starting pumps. It may be of interest to mention that for the first time a new form of oil regulator has been fitted, regulation being according to load instead of as formerly by revolutions per minute. The auxiliary machinery is in a separate room, in which are located three diesel-electric generators supplied by Walschaerts, of Brussels, each of a capacity of 150kW, and a horsepower of 270 at 500 r.p.m. Each engine has six cylinders, having a bore of 235mm and a stroke of 280mm. There is also a small emergency set. There are two two-stage air compressors, delivering air at 25kg per square centimetre. Among other plant are two oil purifiers, while a Cochrane boiler has been installed for heating purposes, and hot and cold air can be supplied to all parts of the vessel. There is a complete sprinkler system for fire-extinguishing purposes.

As is generally realised, both train ferries and car ferries seem specially liable to heavy rolling, even in moderate seas, and for the first time provision has been made to overcome this failing by the provision of Denny-Brown stabilisers which are controlled from the bridge. During trials the sea was very calm and no opportunity was afforded to test this apparatus, but its general efficiency has been adequately demonstrated. Altogether, "Artevelde" is a notable addition to the fine fleet of cross-channel vessels maintained by Belgian Railways and Marine.

The author's thanks are due to Mr. A. Dury, London representative, for the photograph supplied and help given.

High-Voltage Laboratory for Cable Testing

Last week a new high-voltage laboratory for testing cables and accessories at the works of Enfield Cables, Ltd., Brimsdown, Middlesex, was opened by Sir Henry Self, chairman of the Electricity Council. The laboratory is equipped with a twelve-stage 2·4MV impulse generator having 120kW-second stored energy capacity and a high-voltage a.c. testing plant consisting of a series resonant circuit including two transformer/reactor units. With both these units in series test samples can be subjected to a voltage of 2·4MVA for thirty minutes or 1MVA continuously.

A NEW high-voltage laboratory at the works of Enfield Cables, Ltd., Brimsdown, Middlesex, was opened last Friday by Sir Henry Self, chairman of the Electricity Council. Previously the company used a test plant which was first installed in 1926 and was improved and modernised from time to time until it became clear that it would soon be inadequate for research, development and type testing equipment for present-day electricity supply systems. The new laboratory, which is designed to meet the needs of the foreseeable future, contains an impulse generator of 2·4MV, 124kW-seconds, and a high-voltage a.c. testing plant consisting of two transformer/reactor units which, in series, can give a test voltage of 600kV.

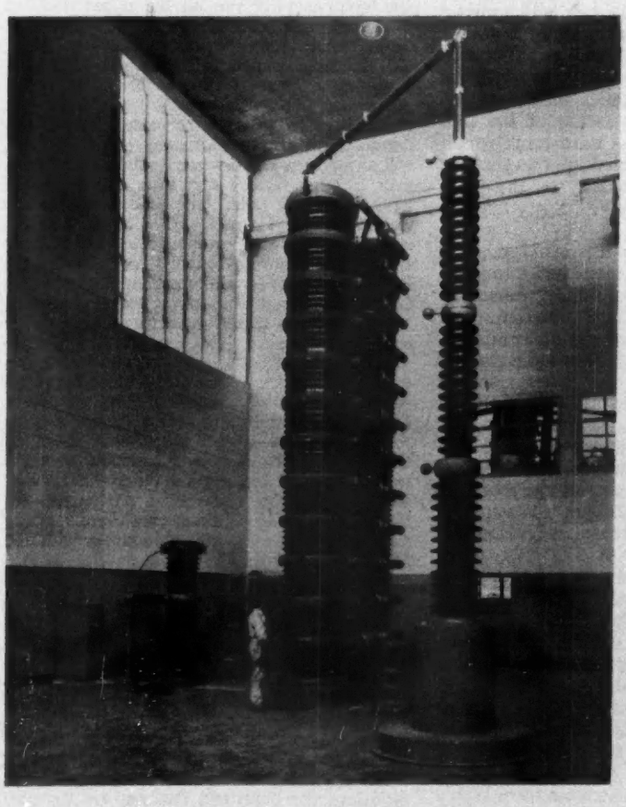
The site for the new building, in the north west corner of the company's sports ground, was originally zoned as a permanent open space, but, with the co-operation of the town planning authority, this plot of land was used instead of the undeveloped eastern end of the sports ground. The site offered some scope for freedom of architectural treatment, but some unusual problems were posed by the proximity of the cooling towers and coal storage areas of Brimsdown power station : it was necessary to prevent condensation and exclude dust. At the same time, satisfactory lighting and acoustic properties were required.

The building is designed to house the high-voltage laboratory, together with a number of auxiliary services. The laboratory itself has a floor area of 9600 square feet (the ground plan being nearly square) and a clear height of nearly 45ft. Adjoining it on the south and forming the front of the building is a four-floor administrative and office block, which has the following accommodation. On the ground floor there are an entrance hall, a number of small laboratory rooms, including a dielectrics laboratory, and a cable jointers' workshop. The second floor contains a control room, an observation foyer overlooking the h.v. laboratory, as can be seen in our third illustration, and a library and managerial offices. The second floor is devoted to offices and laboratory accommodation. Most of the third floor is occupied by drawing-offices and the rest houses the " Plenum " ventilating plant. Behind the laboratory is a ground-floor annexe containing stores and a service substation. West of the laboratory there is garage accommodation for mobile test vans.

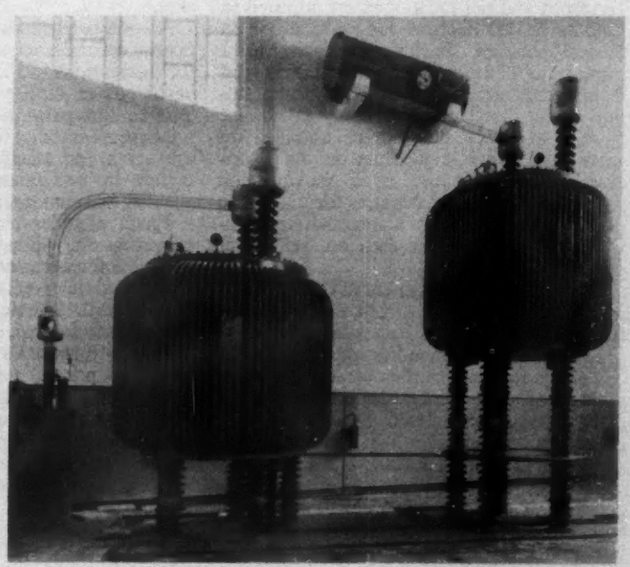
The main requirements for the building itself were that it should house the high-voltage test equipment with the necessary clearance against flashover to walls and roof. A reinforced concrete frame carries the main structure, which consists of 18in square columns at 15ft spacing, with prestressed concrete beams, 3ft 6in deep and at 7ft 6in spacing, spanning the 80ft roof. Between the external columns are panels of cellular breeze blocks inside and concrete blocks outside. The inside surface is of insulating boarding on battens with sufficient acoustic tiling to give the desired reverberation period in the laboratory. The outside surface is treated with vermiculite-spattered rendering coloured grey to give an expression to the bulk of the laboratory in contrast to the auxiliary rooms which are clad with brickwork.

Natural lighting is provided in the laboratory from a continuously glazed clerestory infilling on the north side, supplemented by east and west windows, which have vertical louvres of prestressed concrete to exclude direct sunlight. A Plenum system is installed to control the humidity in the laboratory, and to exclude fly ash and other impurities. Heating for the remainder of the building is by conventional low-pressure central heating. Both systems are served by a steam supply from the main factory, through calorifiers on the third floor. Some of the spaces between the prestressed roof beams are used to house the air ducts for the Plenum system : other spaces contain inspection walkways and electrical conduits. To give adequate lighting factor at floor level twelve 1000W mercury-tungsten lamps and reflectors were installed at roof height. To provide satisfactory acoustics in a laboratory of this size it was decided to introduce acoustic absorbent material in the roof, using spattered vermiculite on metal lathing suspended below the beams. We learn that this lining together with insulation boarding and a calculated area of acoustic tiling 12ft above floor level, has reduced the period of vibration to 1·9 seconds. It was not considered advisable to continue the absorbent materials to floor level. Instead there is a hard wall surface to a height of 7ft with a cement cold glaze on cement rendering.

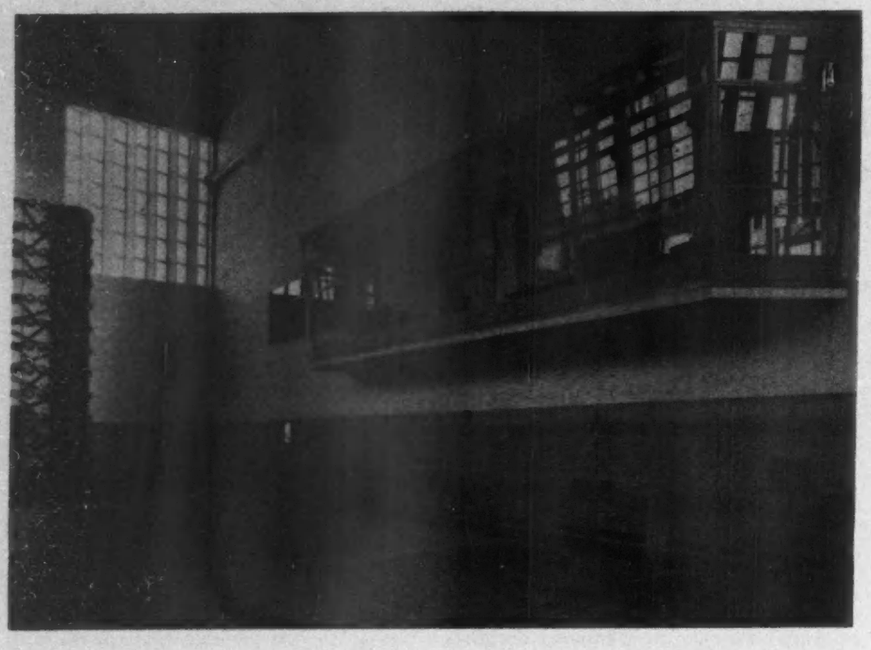
For the floor of the laboratory, which has to withstand heavy weights and be " non-dusting " and oil proof, a surface of heather-



Twelve-stage impulse generator of 2·4MV, 120kW-seconds with charging rectifier on the left and 270 picofarad potential divider on the right



600kV 2·4MVA series resonant transformer/reactor units with feed transformer on the left



Control room window as seen from the floor of the testing laboratory. Beyond the control room on the first floor are an observation foyer, library and managerial offices. Above these suites there are offices on the second floor and drawing-offices on the third floor

brown tiles was chosen. A more continuous system of treatment was inadmissible because of the need to allow for cable ducts, bases for testing equipment, and guard rail stanchions. The roof is flat and strong enough to be used for the testing of cables and accessories outdoors.

The building was designed by Messrs. Douglas and J. D. Wood, London, W.1, architects, in consultation with Messrs. Wells and Walchli, London, W.1, quantity surveyors, and J. Bak, A.M.Inst.C.E., London, S.W.1, consulting engineer. The main contractors were Marshall Andrew and Co., Ltd., of 31, Queen Anne's Gate, London, S.W.1.

As already indicated there are two main items of test equipment—an impulse generator and a high-voltage a.c. test plant. The impulse generator (page 99) is a twelve-stage, two-column installation with an output voltage of 2·4MV and a stored energy of 120kW-seconds. Shedded porcelains house the stage capacitors and the spacers. The front and tail resistances are adjusted to produce a 1/50 microsecond wave shape on the test specimen. Each stage capacitor has a capacitance of 0·5 micro-farad and is charged from a d.c. charging equipment incorporating metal rectifiers so that a voltage from 0 to 200kV d.c. can be obtained on each stage, the voltage being infinitely variable through the use of a moving coil regulator. There are facilities for automatic polarity changeover by a motor-driven contact arm which can be seen on the left of our first illustration.

By a simple rearrangement of the generator and replacement of the front resistances the full stored energy can be made available at 1·2MV without dismantling the capacitors.

Voltage measurement is by a capacitance divider of 270 picofarads constructed in three sections, terminated by a low-voltage capacitance of variable steps which is fully shielded and of low inductance. A lead of low capacitance is taken from the divider to a cathode-ray oscillograph which is sealed off, with two tubes operating at about 15kV and two cameras whereby photographic recording can be made on both tubes. A common tripping circuit is used so that it is possible to obtain two independent records of the conditions in a circuit from a single applied impulse.

A series resonant circuit forms the basis of the high-voltage a.c. testing plant (page 99). The power supply for this circuit is taken from the 11kV system through circuit breakers and a moving-coil voltage regulator to a feed transformer of 400kVA, thirty minutes rating. The secondary winding of the feed transformer is connected in series with the test sample and the two transformer/reactor units. Each of the transformer/reactor units is designed to operate at 300kV on the secondary winding. With both units in series a voltage of 600kV can be impressed on the test sample with a rating of 2·4MVA for thirty minutes, or 1·0MVA continuously. The reactance of each unit can be varied approximately 40 : 1 between maximum and minimum setting. The rating of the feed transformer is such that a third transformer/reactor unit could be added later so that the ultimate output and capacity of the plant would be 900kV at 3·6MVA, thirty minutes rating.

A voltage-regulating unit is installed. It is operated from a capacitance divider to allow for fluctuations in the test voltage caused by variations of supply voltage and frequency. This compensation is specially important for a long-time stability test. Four main reasons are given for selecting the series resonant circuit in preference to the conventional parallel resonant circuit.

First, considerable improvement is obtained in the voltage wave-form which is desirable for accurate peak voltage measurement, and it is easier to get precision of balance with Schering bridge measurements on the test sample.

Secondly, should a test sample break down when the parallel resonant circuit is used a considerable short circuit is developed across the fault and it would damage the sample. When the series resonant circuit is used a breakdown of the sample de-tunes the circuit and the fault current drops to a fraction of its normal value. This safeguard limits damage at the point of failure and assists in subsequent examination of the fault.

Thirdly, the series resonant circuit is highly suitable either for series or parallel connection of the reactor/transformer units.

Fourthly, the power for the test equipment is supplied at unity power factor.

A pair of 1·5m diameter spheres, motorised for remote control from the control room, is installed for voltage measurement.

Earth plates have been provided for both the a.c. testing plant and the impulse plant ; on the latter all earth connections are taken back to one common point. The building is not screened.

The impulse generator and the high-voltage test plant were supplied by Ferranti, Ltd., of Hollinwood, Lancashire.

At the end of a luncheon following the official opening of the laboratory the company's guests were shown, on a closed circuit television system, tests being carried out on a sample of a new 400kV single-core cable. This cable has a stranded copper core shaped to an oval cross section. It is insulated with oil-impregnated paper, covered by a lead sheath, with copper tape reinforcement. In the space between this inner lead sheath and a similarly reinforced outer lead sheath nitrogen gas is maintained at a pressure of 200 lb per square inch. This pressure exerted on the inner sheath is designed to minimise the formation of voids in the cable dielectric. The two ends of the test cable specimen are terminated by sealing ends incorporating hand-applied condenser cones.

West London Motorway

In our issue of March 28 last, we described and commented upon the Minister of Transport and Civil Aviation's plan to build a motor road through the urban areas on the western approach to London. The Minister has now published the proposed line of a motorway nearly 12 miles long, leading from the Chiswick Fly-over, on the western outskirts of London, to the start of the projected Slough–Maidenhead By-pass on the London–Bath road, A4. A spur road 1 mile long will connect with London Airport. The cost is estimated at about £12,000,000.

As previously announced, the first part of the motorway will run on the upper deck of a two-tier road constructed for the first mile of its length along the line of the Great West Road. Single supporting piers will be erected along the centre strip of the Great West Road allowing traffic to pass freely along the dual carriageways on either side. Where the two roads diverge, the motorway, still on viaduct, will swing in a north-westerly direction to pass over a large factory and then descend gradually to ground level. The total length of the viaduct will be 1½ miles. The motorway will continue at or near ground level for another 10 miles from Boston Manor Park to the Slough By-pass. Except for an interchange point on the Great West Road near Lionel Road, there will be no no access to the motorway from existing roads until it reaches Cranford Parkway (Route A312) where a fly-over junction with link roads will be built. Provision will be made for a fly-over at the junction with the proposed North Orbital Road at Richings Park, and the spur road to London Airport will also be linked to the motorway by a fly-over junction. At the western end of the scheme there will be link roads to a surface roundabout on the A4, but the motorway will continue over the top of the roundabout on a fly-over to connect with the Slough–Maidenhead By-pass.

West of the viaduct twenty-nine bridges will be built, ten of which will carry the motorway over waterways, three over or under railways, and eleven over or under secondary roads. The other five will be at fly-over junctions. The viaduct will be designed to carry full standard loading. This means in effect that it will be for the use of all motor vehicles except articulated vehicles carrying abnormal loads. The average height of the viaduct will be 25ft, but where it passes over a factory at the western end it may rise to 65ft. Sir Alexander Gibb and Partners are the consulting engineers appointed to prepare the scheme to contract-letting stage.

Institution of Naval Architects in France

No. I

MEMBERS of the Institution of Naval Architects travelled from this country to join the foreign members of the Institution in Paris where the summer meeting was held at the invitation of the Association Technique Maritime et Aeronautique. About 180 members and their ladies made the journey to attend the joint meeting, the programme of which, besides including the reading and discussion of technical papers, provided an opportunity for seeing something of the beauties of the capital of France and for admiring the architectural beauty of the cathedrals of Notre Dame, of Rouen and the castle of Chantilly.

On Monday, June 30, before the formal opening of the meeting on the next day, there was a reception at the Hotel George V. On the morning of Tuesday, July 1, the ladies were able to visit the Maison de Couture Maggy Rouff and during the afternoon the members spent a few hours in the Musée de la Marine, Palais de Chaillot, seeing a display of models and paintings which trace French naval history over the centuries to modern times. The models included galleys, sloops, frigates, famous ships of the line and demonstrated the transition from sail to steam, the introduction of armour and the development of armaments from muzzle loading guns to the gun turret. All these developments were seen embodied in the "Richelieu." Many naval occasions are recorded by the paintings, and of particular interest are those having as their subject the ports of France. The events of the day concluded with a dinner, which was held in the Hotel Continental and given by the Institution of Naval Architects, with Viscount Runciman in the chair. Toasts were drunk to the President of the Republic and Her Majesty the Queen, and Viscount Runciman then proposed the toast of "L'Association Technique Maritime et Aeronautique," while Monsieur Georges Bourgès proposed the toast of "The Institution of Naval Architects." Monsieur Bourgès recalled that the last joint meeting in Paris was held in 1931, when Lord Wester Wemyss, a companion of Marshal Foch, was president of the Institution of Naval Architects, and was pleased to call attention to the work of John Scott Russell, William Froude, Rankine and Sir Charles Parsons among many others.

A tour of old Paris with visits to Sainte-Chapelle and Notre Dame occupied the ladies on the morning of Wednesday and all members attending the joint meeting boarded launches for lunch and to enjoy a river trip and to see the famous bridges and many buildings from a different point of view. Later the members and their ladies attended a reception held at the Ministry of Marine. The whole of Thursday was given over to a visit to Rouen and Le Trait, a special Pullman train conveying the party to Rouen from where the rest of the journey to Le Trait was made by road. Here a tour was made of the Ateliers et Chantiers de la Seine Maritime, which has eight building berths and can construct oil tankers of 24,000 tons deadweight. The yard, on the right bank of the Seine, has an area of about 65 acres, including workshops having a floor area of over 500,000 square feet. It has been largely reconstructed, to make good the heavy damage suffered during the war, so that the equipment is modern, and adequate provision made for large prefabricated units. It was of interest to note that the company has built a garden city to accommodate its personnel and has established various social organisations for their benefit. The Ateliers et Chantiers de la Seine Maritime hospitably filled the role of host for lunch to which a welcome was given by Monsieur Robert Labbé, the president of the company. Afterwards the party visited the ruins of the historic Abbey of Jumieges before returning to Rouen and having the opportunity of seeing the famous cathedral and of appreciating its architectural beauty which has been restored following reconstruction to repair extensive war damage.

The afternoon and evening of Friday, the final day of the joint meeting, were spent at the Castle of Chantilly. A short tour of the castle was followed by tea in the Park where the company was entertained by an exhibition of dressage followed by a Carrousel by a squadron of Spahis of Senlis. The Spahis in their colourful uniforms performed a number of skilful manœuvres and gave altogether a wonderful and exhilarating display of horsemanship. Dinner was served in the "Grandes Ecuries" of the Castle, which had been specially decorated for the purpose, and the guests were entertained by hunting calls played by the Cor de Chasse, who had indeed made the visit a memorable one by appearing at different points on the tour to give a performance of the music of the hunt. At the dinner a valedictory speech was made by Monsieur Georges Bourgès and Viscount Runciman of Doxford, the president of the Institution of Naval Architects, thanked the French hosts, on behalf of the members and their ladies, for their generous hospitality and for the splendid programme and for the efficiency of the arrangements which had been made by Monsieur Raymond Puech. The evening concluded with a performance of "Son et Lumiere," relating something of the history of Chantilly, which dates back to Roman times.

Technical Sessions

The technical sessions were held on the mornings of Tuesday, July 1, Wednesday, July 2, and Friday, July 4, and six papers were read and discussed.

The meeting opened on Tuesday morning in the lecture room of the Musée Guimet, when the delegates were welcomed by Monsieur G. Bourgès, the president of the Association Technique Maritime et Aéronautique. Viscount Runciman, the president of the Institution of Naval Architects, replied, and then took the chair for the first technical session. The first paper presented to the meeting was :

SOME PROBLEMS IN THE CONSTRUCTION OF WARSHIPS TO-DAY

By P. Gisserot

Translation by W. C. S. Wigley, M.A.

Synopsis

The problem of space has become of much more importance in the designs of new warships than was previously the case. For this reason many ships have been built with relatively large superstructures ; this in turn, has created problems which are briefly examined in the paper. The question of accommodation is also involved in the problem of space, and in this connection some remarks on ventilation are added. The paper ends with some reflections on the considerably greater need for technologists and the necessity for building ships which can to a certain extent be adapted to the evolution of arms and equipment.

Discussion

Sir Victor G. Shepheard : As one would expect, the problems cited by the author are also those which face British naval constructors, and no doubt we are both tackling these problems on the same general lines. I agree entirely that our greatest problem to-day is how to utilise to the best advantage the space available. Gone are the days of heavy concentrated loads such as armour, gun turrets and armour-piercing shell. Instead, our ships carry relatively light weight equipment, such as aircraft, guided weapons and electronic apparatus. The problem is made more acute by the fact that modern equipments themselves not only require much more space, but they also need larger ships' complements for their operation and maintenance.

It is obvious that if warships are to be of reasonable size for the armaments they carry and provide acceptable living conditions, the complements must be restricted to a workable minimum and work study investigations are now being carried out in the Royal Navy.

As in the French Navy, considerable attention has been given to improving the living conditions in British warships. And quite rightly so, for it is only in this way that we are likely to attract the type of recruit needed to operate and maintain the complicated equipment necessary in this highly scientific age. All the latest ships being built for the Royal Navy will have bunk sleeping, cafeteria messing and full air conditioning.

Ship stabilisation is being incorporated in our latest warship designs. Ventilation and the removal of the heat generated by the vast amount of electrical equipment in warships is, indeed, a serious one. It is time the electrical and electronic engineers discovered more efficient means of utilising electrical energy without the production of so much waste heat, which is so difficult and so expensive to remove from ships.

The magnitude of the ventilation problem can be appreciated from Table I of the paper. In a light modern aircraft carrier, for example, the supply fans introduce into the ship 350,000 cubic metres of air per hour. This means that 11,000 tons of air is blown into the ship every twenty-four hours, which is equivalent to about half the total weight of the ship per day. In order to reduce the sizes of ventilation trunks in ships, the tendency is to increase the velocity of flow. This, unfortunately, gives rise to increased noise transmitted by the fans and trunking, and this problem is now the subject of research in the United Kingdom.

The adoption of full air conditioning in ships somewhat eases the problem of ventilation in that the quantity of air introduced from outside and distributed through the ship is less, and, therefore, the sizes and weights of the trunking are smaller.

I endorse the sentiment expressed by the author in the final sentence of his paper ; it is the difficulties and problems which the naval constructor is constantly called upon to solve that makes his profession so attractive.

Monsieur Louis Kahn : Monsieur Gisserot has laid before us some of the problems which face naval architects to-day, and has pointed

out that although each generation has its own problems it will leave even more difficult problems to its successors.

The origin of these problems is to assure the freedom of sea communications and the means of attack and defence. On one hand, evolution is taking place at a rate which is fast when compared with the working life of a ship constructor, while, on the other hand, increased costs pose financial problems within the national economy.

It has not always been like this. For example, in the seventeenth century, Richelieu and then Colbert inspired the naval policies of France, and were lucky enough to operate in a period of relative technical stability. Their problems were those of size, continuity and finance. Mr. Stoot will demonstrate to us tomorrow that all this changed in the next century and has hardly slackened since. Perhaps we have known one such epoch, between 1919 and 1935, although our serenity was perhaps due to a lack of awareness of the facts we would have to meet later.

The factors which have changed in the last century are basic—materials, motive power, hull forms and propellers, high-powered guns, armour-plating and even steel of high elastic limit which can be welded, all of which have transformed naval warfare vessels.

There are two problems to be faced ; one is that our function cannot remain merely that of the assembler, and the other is that it is now impossible to equip a student for all his professional existence.

Mr. A. R. Mitchell : I wish to raise with the author the subject of the preservation of structure. The corrosion in the hull structure of intermediate naval vessels such as destroyers and frigates built during the war years was very severe, and probably this was because the structure was not galvanised, which had been the normal practice before the war. With the post-war adoption of completely welded construction for such vessels we have decided that it is no longer practicable to return to hot galvanising because of the inconvenience to the operator and other technical difficulties of welding and burning.

The alternative is to shot blast and zinc spray those parts of the structure which experience has shown are most liable to corrosion. Such areas are the bilges, wet compartments, and deck and ship side intersections. This process seems to be proving satisfactory as a method of reducing corrosion, but causes a delay in building, since other trades cannot work in the compartment when it is being shot blasted. A second alternative is to use vacuum blasting equipment, which causes very little interference with other workmen in the vicinity. At the moment this process is proving to be somewhat slower than open blasting, but it may improve in this respect as we gain experience.

Would the author say what arrangements the French Navy makes for the preservation of the structures of the ships it is now building?

Monsieur Amiot : Monsieur Gisserot has shown the importance of the problem of interior space in a modern warship. Taking for example " Mogador " to " Surcouf," the interior space taken by military installations has doubled in surface area, and increased in volume by 50 per cent.

Many consequences result, and the paper mentions that the verification of the balance of volumes becomes essential in the establishment of a project ; there is also mention of the development of the superstructures.

From the cruiser " Algerie " to the cruiser " Colbert," of similar speeds, the ratio of total interior volume to volume of hull passed from 2·4 to 3·4 and with the " Mogador " to " Surcouf " after deduction of the volume of machinery space in order to take account of the differences of speed, the ratio passed from 1·75 to 2·65. The development of superstructures poses the problem of the height of the centre of gravity, not only because of the weight of the superstructures themselves, but in addition the weight of the equipment carried. Owing to the increase in the ratio already mentioned, the designer has to choose a hull volume that is a displacement greater than the equation of weights requires.

In recent projects, where it is a question of aircraft carrier, or of fast frigates, it appears that the problems of space required determines the total length.

One can say that the designer will choose coefficients of values considered as limits to assure that the hull satisfies the requirements of stability and interior space.

The disposition of weight, therefore, conditions the displacement by the determining influence of the centre of gravity. This consideration will influence future projects since it appears necessary to take into consideration the risk of atomic blast, and the reinforcement necessary to resist high pressures.

Therefore you will see that the weight factor remains important. Experience has demonstrated that the control of weight is not always practicable. Therefore, in spite of the margin given by the displacement equation, naval architects should constantly keep the question of weight before them.

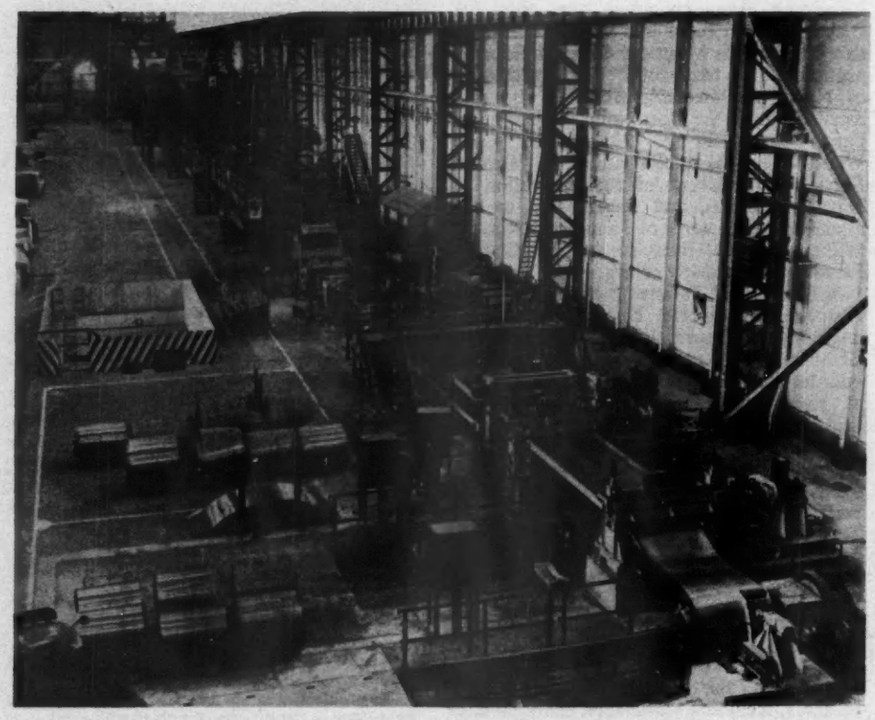
(To be continued)

Continuous Galvanising Line

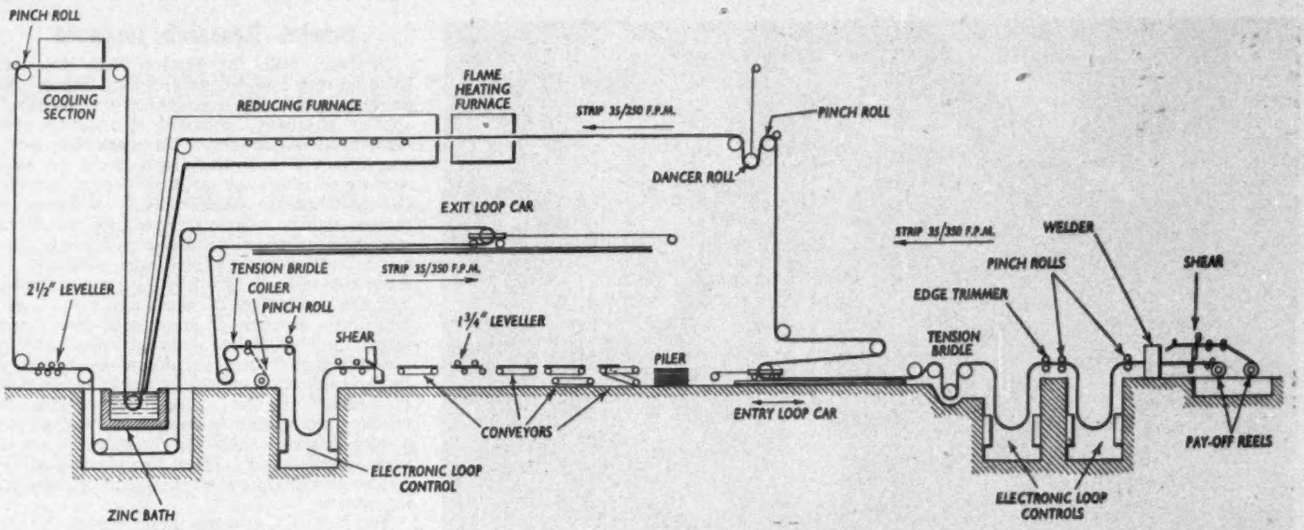
A continuous galvanising line for strip up to 48in wide installed at the Ebbw Vale works of Richard Thomas and Baldwins, Ltd., has a potential output of 10 tons per hour of galvanised steel in the form of coil or sheet. This installation is based upon the Sendzimir process of galvanising and is fully automatic in operation.

WE recently visited the Ebbw Vale works of Richard Thomas and Baldwins, Ltd., to see the new continuous galvanising plant of Armco–Sendzimir design which has been installed and is now in full production. This line has a potential output of 10 tons an hour of galvanised steel in the form of either coil or sheet and it can galvanise strip up to 48in wide. It is based upon the Sendzimir process which is stated to overcome certain drawbacks of steel sheets galvanised by conventional methods, and provide sheets with a coating having a degree of adherence sufficient to withstand the effects of subsequent drawing and forming operations up to the limit of the steel base without peeling or flaking. In the new plant which is some 700ft long the strip in one continuous operation is cleaned, heat-treated pickled, coated and reeled or sheared to size. The main contractor responsible for the plant was the Head Wrightson Machine Company, Ltd., the whole of the electrical equipment being supplied by the English Electric Company, Ltd., and the furnace equipment by Birlec, Ltd.

The general lay-out of the continuous galvanising line can be seen in the diagram and photographs we reproduce. At the entry of the line two pay-off reels are installed, one being in use whilst the other is being loaded to maintain continuity of feed. As



The galvanising line from the entry end

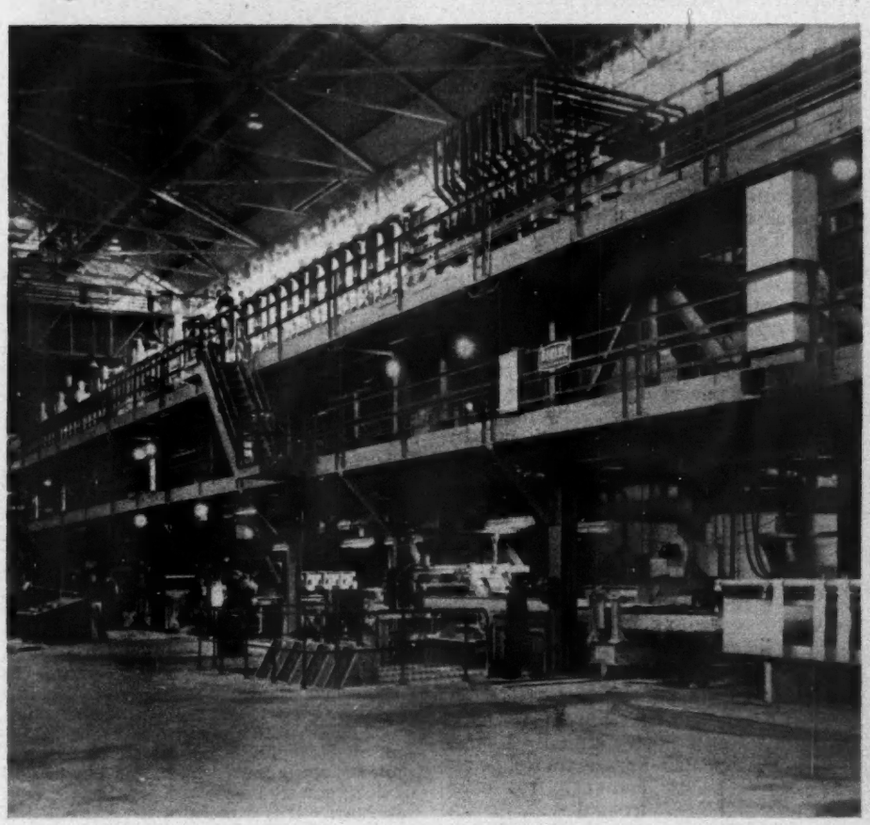


Schematic section through galvanising line

the tail end of one coil passes from its reel the leading end of the next coil on the other reel is spot welded on to it after having been trimmed in a shear. Air-operated water-cooled brakes on the reels maintain a degree of back tension on the strip as it is pulled off by the first of pinch rolls beyond the welding set. These pinch rolls feed the strip into a looping pit from which it is drawn by a second set of pinch rolls and passed through an edge trimmer. A second looping pit is situated beyond the edge trimmer and electronic gear in the pits control loop size through the drives.

From the second looping pit the strip is carried through a tension bridle feeding into a long entry loop. In this loop the strip passes over a traversing car and this arrangement is designed to provide an accumulation of strip sufficient to maintain a continuous supply to the furnace section of the installation whilst the entry section is stopped for the trimming and welding operations involved in coil changing. A set of pinch rolls at the top of the main overhead structure pulls the strip from the entry loop and feeds it into a vertical balancing loop fitted with a weighted " dancer " roll.

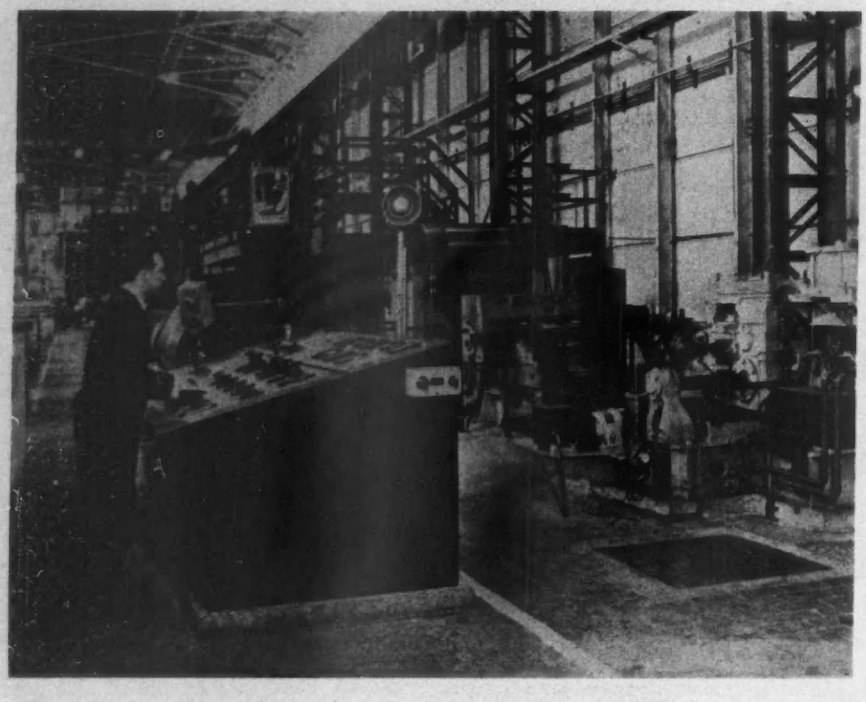
The whole of the furnace installation is carried on an overhead structure and in it the strip first passes through a gas-fired flame heating section. In this section an open flame cleans off any contamination and lightly oxidises the surface of the metal. Immediately after the heating operation the strip passes into the heating section of a reducing furnace fitted with gas-fired radiant tubes. In the following electrically-heated section of this furnace the strip is maintained at a constant temperature in an atmosphere of dissociated ammonia which reduces the oxide formed in the flame-heating section to give a matt surface. The heating zones of the furnace are controlled at 1750 deg. to 1800 deg. Fah. giving a strip temperature of 1550 deg. Fah. for annealing or 1750 deg. Fah. for normalising, and strip temperature is controlled by the speed at which it is drawn through the heating zones. In the four cooling zones of the furnace the temperature of the strip is reduced to that at which it is required to enter the galvanising bath in the next stage. The strip passes directly from the final cooling zone into an enclosed trunking extending down to below floor level below the surface of molten zinc in the galvanising bath. The metal thus enters the zinc in an annealed state with a matt surface free of oxide or surface contamination giving the ideal conditions for zinc adhesion. As the strip leaves the galvanising pot, in which the zinc is maintained at a temperature of 835 deg. to 870 deg. Fah., it passes between a pair of coating rolls which serve to control the thickness of the zinc coating.



Overhead furnace installation with strip shearing and piling section on floor below

The galvanised strip is drawn vertically upwards from the pot and past a group of cooling blowers near roof level by a set of pinch rolls, before it passes down to floor level and through a roller leveller. A second long horizontal looping section with a tensioning roller car provides a large storage loop of material to ensure continuity during initial feed changing operations. The production line is completed by a tension bridle and a small looping pit leading to a Halden flying shear which cuts the strip into the required lengths and deposits them on to a conveyor system. This conveyer feeds the sheets into a leveller, through a classifier section and on to a pilot. When the galvanised strip is required in coils it is coiled on a machine set on the line before the small looping pit.

For this installation the English Electric Company, Ltd., supplied nineteen Ward-Leonard d.c. drives. The line itself is divided into three sections, i.e. entry, furnace and exit sections. The drives in each of these sections are speed matched but the sections may vary with respect to each other by taking out or paying strip into either of the horizontal loops. With the exception of the final classifier section of the line which handles sheets and requires less critical speed control each Ward-Leonard drive is supplied from its own generator. The generators of each group have their fields supplied from a variable voltage exciter in turn excited through a motorised rheostat which sets the section speed.



Entry section control desk with tension bridle and edge trimmer

Special control facilities are included to suit the individual drives. The generator feeding the first pinch roll in the line beyond the welder has trimming by means of a modulated light control from photocells arranged in the first looping pit to maintain the loop depth constant. A similar control applied to the two tension bridle drives, is controlled from the second looping pit. The generator of the pinch roll feeding into the vertical balancing loop before the furnace section has a trimmer rheostat in its field which is controlled by the position of the dancer roll.

The speed of pinch roll in the cooling section of the line beyond the furnaces, on which the success of the process depends, is controlled by a magnetic amplifier which measures the difference between a set reference and the actual speed of the pinch roll, and adjusts the speed to reduce any error to the minimum. A similar control is applied to the leveller on the floor below but in this case regulation is introduced so that the tension between the two drives may be controlled.

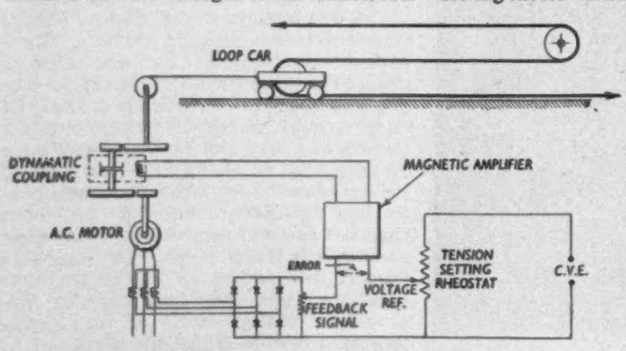
The speed of the galvanised strip coiler is controlled by a magnetic amplifier acting in its motor field circuit. As the diameter of the coil increases so the speed of the strip tends to increase. This tendency is detected by a pilot exciter coupled to a pinch roll which causes the output of a magnetic amplifier to increase the field strength of the tension reel motor so preventing more than a very small increase in strip speed. When strip is being sheared to length the speed of the final pinch roll is adjusted by modulated light control using photocells in the looping pit.

In order to maintain the correct speed relationship between drives in all three sections and to ease the duty imposed on the automatic control systems, every drive has an IR compensation acting through its generator and so giving a uniform regulation irrespective of Ward-Leonard voltage variation.

Of the numerous a.c. drives, three are of particular interest being used to control the tension in the entry and exit loops and in the dancer roll. A diagram we reproduce shows a typical arrangement of one of the loops. The strip passes round a roll on the loop car which is pulled towards a winch by a cable and the drive to the winch incorporates a "Dynamatic" magnetic slip coupling driven by a 60 h.p. a.c. motor.

The tension of the strip is proportional to the torque transmitted by the coupling which in turn is proportional to the torque delivered by the driving motor. The torque transmitted by the coupling is largely proportional to its excitation current but may vary under conditions of paying out and taking up of loop. To avoid the resulting variation in strip tension a servo control is included which compares the stator current of the driving motor with a chosen reference. Any error between these is amplified and used to excite the coupling in such a manner that the driving motor stator current and the strip tension are held constant at the chosen value.

A loudspeaker system provides intercommunication between various control points, and apart from maintenance staff, the line is worked by only seven men.



Schematic diagram of a loop car tension control drive

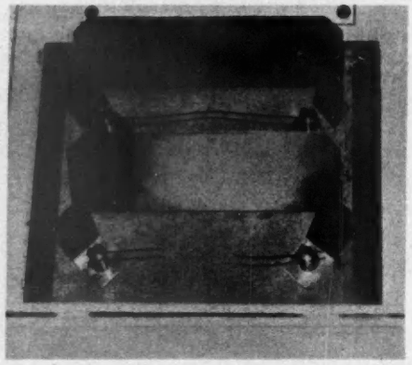
Sondes Research Institute

In June, 1948, the Sondes Place Research Institute was founded at Dorking, Surrey, to perform sponsored research in the fields of applied chemistry, chemical engineering and mechanical engineering. To mark the tenth anniversary of the Institute an open day was held recently at which the guest of honour was Sir George Thomson, D.Sc., F.R.S. Subjects of current activity include fuel cells for the direct conversion of chemical to electrical energy, the stability of super-saturated gas solutions in water (control of "gushing" in bottled beer), and the production of chemicals from sugar. Since this research is sponsored, details are usually not available, although the Institute observes that "firms are beginning to take a more enlightened attitude towards publication of research results . . . the policy-makers in industry are coming to appreciate that research cannot flourish without the cross-fertilisation of ideas which results from free discussion"—but we mention below some projects of engineering interest.

The N.R.D.C.-Ricardo steam engine, for use in undeveloped countries, was seen in action for log-sawing, the furnace being stoked with the logs. Development running has been performed on straight mineral oil, and a display of components showed such modes of failure as scoring of the full height of the piston, rubbing of the rod half of a big-end bearing (the aluminium alloy connecting-rods do not run direct on the crank), and abrasion of tappets (a sectioned engine demonstrated that tappet rotation was occasional).

Various aspects of electrodialysis are also under investigation, and it was observed that the extraction of common salt could form a part of the process of sugar refining, possibly increasing the sugar yield at the expense of that of molasses.

A method of producing high-temperature resisting coatings for metals that is accorded special interest is vapour diffusion. Our illustration shows two molybdenum wires : the lower



The effect of exposure at 1200 deg. Cent. on molybdenum wires, the upper alone having a siliceous coating

has been oxidised away by two minutes' exposure at 1200 deg. Cent., whereas the upper is intact and, it is found, will survive 1500 hours at that temperature. The coating is of molybdenum disilicide, formed by exposure of the part at its working temperature to an atmosphere of silicon tetrachloride and hydrogen. While the coefficients of expansion of metal and silicide are not equal, the coating is unstressed at working temperature by virtue of having formed at that temperature ; at lower temperatures cracks appear, but it is found that if cooling is rapid the base metal can be cooled below the oxidising range before reaction becomes damaging—an attractive characteristic for turbine blades. To render the cracking of the coating random, it is necessary to control the thickness of the coating, say, 0·0015in, within a few per cent. No inspection of the coating is possible at present, and protected components must be tested by thermal cycling ; as explained, slow cycling is most searching. It is expected that this method of coating will confer an improved resistance to reaction with vanadium pentoxide.

SHORTER REPORTS

Diesel-Hydraulic Traction

THE British Railways plan for the Western Region for the replacement of steam by diesel traction includes, as a first stage, the use of diesel-hydraulic locomotives on the majority of the passenger and freight services between Newton Abbot and Penzance and on many of the through trains between Paddington, Bristol and the West of England.

This programme involves the replacement of over 200 steam locomotives by approximately 130 diesel-hydraulic main line locomotives. The first of thirty-three which are being built in the Swindon Works was this week named " Sir Brian Robertson " after the chairman of the British Transport Commission. With this one exception all the locomotives will be named after warships and constitute, with the North British Locomotive Company productions, the " Warship " class. One example has already been illustrated in our pages, the D.600 " Active " on Plate 4, January 3 last.

The provision of diesel-hydraulic locomotives was discussed in some detail on page 792, November 29, 1957. The design of the locomotives being built at Swindon is based upon that of the V.200 class of the German Federal Railways, but the British Railways loading gauge imposed a reduction of about 10in in height and 16in in width. The total weight of 78 tons is spread equally over four axles, all of which are driven.

The twin engines are Maybach V-12 water-cooled units, those of the first three locomotives giving 1056 b.h.p. at 1400 r.p.m. and subsequent productions 1152 b.h.p. at 1530 r.p.m. They are distinguished by mechanically-driven L'Orange injectors and twin overhead camshafts, but the engine speeds are low enough to allow the piston heads and ring carriers to be detachable, thus facilitating maintenance. The six-throw crankshaft has exceptionally large main bearings which overlap the greater part of the relatively small crankpins and which render the crank webs virtually non-existent ; the main bearings running on rollers, the construction of the crankcase becomes particularly simple. This is noteworthy as one of the few examples of roller bearings on a shaft not of built-up construction. Since the connecting rod bearings are plain, an electric-oil pump supplements the normal pump at starting. Maybach turbo-chargers are used ; a fuel consumption of 0·375 lb per horsepower-hour is claimed. In view of the fact that Maybach has granted a licence to Armstrong Siddeley Motors, Ltd., it is possible that spare parts or replacement engines may be obtainable here.

The transmission is essentially different from that of the North British vehicles (which is entirely hydro-kinetic), being the Maybach " Mekydro " with a single converter and a four-speed box. The ratio changes are not torque sustained, the drive being discontinued by withdrawing the turbine from the converter axially. Changes are automatic and effected hydraulically. Engine, transmission, and the unsprung final drives are linked by Cardan shafts similar to those of the V.200 engines.

Automatic train control equipment is installed. The engine and transmissions are continuously monitored for lubrication or cooling abnormalities.

The auxiliaries are varied in nature; as already mentioned, the transmission is operated hydraulically, and so also is the radiator fan, which has a 1500 lb per square inch supply. The radiator shutters are operated by the same hydraulic circuit as controls the fan motor. Electric batteries are carried to start the engines by means of dynamotors which, when the engines are running, supply the injector control system. Braking of the locomotive itself, sanding and windscreen wiping are by compressed air.

The 2200 h.p. diesel-hydraulic locomotive built by British Railways

Third Report of CERN

THE third report of CERN, the European Organisation for Nuclear Research, has now been issued. It covers activities for the year 1957. According to the report the construction of accelerators and buildings at Meyrin, near Geneva, went as planned, and by the end of November the whole staff had moved in. The 600 MeV synchro-cyclotron started working on August 1, almost exactly on schedule (an account of this machine appears in THE ENGINEER for October 11, 1957, page 538). The construction of the 25 GeV proton synchrotron* is also going ahead as foreseen, and the preparation of a research programme has begun. This accelerator is expected to come into operation in 1960. Heavy experimental equipment for the machine may take a few years to build, but should be available in time for the work in the research programme. During 1957 the staff concerned with the proton synchrotron passed the stage of design, planning and ordering, and entered upon the most active phase of building. The last major contract (for evacuating equipment) was placed at the end of the year. Components of the linear accelerator are stated to be in course of assembly ; this machine is 30m long and will " inject " particles into the synchrotron. Parts of the magnet were received on the site without appreciable delays, and the magnetic and mechanical tests were satisfactory. A group attached to the Proton Synchrotron Division is studying possible new techniques in the construction of high-energy accelerators. These studies are thought to be especially important because CERN may extend its programme later.

The development of new experimental techniques at CERN was intensified during 1957, particularly in the work on liquid hydrogen bubble chambers. The hydrogen liquefying plant was finally installed early in the summer ; in this, compression to about 100 atmospheres is followed by cooling in heat exchangers bathed in liquid nitrogen. About 32 litres of liquid hydrogen are produced per hour. A 10cm bubble chamber of stainless steel was built during the year. This was by way of being a pilot apparatus, incidentally useful for training staff, and the design of a 30cm chamber was completed while the 10cm chamber was under test. The processing of data from particle-track visualising instruments such as cloud or bubble chambers is another subject of study at CERN. Digital computers are to be used to obtain such results as spatial co-ordinates, angles between tracks, curvatures, &c. Photographic information will be translated into a punched code suitable for the computer. A prototype translator tested at CERN uses a projection microscope. A fixed pointer is manually aligned with the interesting point on the enlarged image, and the motion of the mechanical stage of the microscope is sensed by counting optical interference fringes electronically.

From October 1 all theoretical studies were concentrated in Geneva, and the offshoot in Copenhagen (which functioned at first under Niels Bohr and later under Professor Møller) ended its work. Co-operation with other scientific institutes during 1957 included participation in conferences and colloquia held in the United States, western Germany, France and Israel. Preparation for the eighth annual conference on high-energy nuclear research is under way.

* See THE ENGINEER, August 17, 1956, page 243.

Search for Uranium

THE activity of the Atomic Energy Division of the Geological Survey in the search for uranium is little known because until comparatively recently information has been withheld. The Division was created during the last war, and since that time it has played an important part in production and in the search for raw materials in many of the countries of the Commonwealth. Close co-operation is maintained with the Atomic Energy Authority, on whose behalf the work is undertaken. We learn from an account given by the D.S.I.R. that the Atomic Energy Division has grown to be a major branch of the Geological Survey. The assistance it can give ranges from radiometric assaying and the preparation of mineralogical reports to field surveys and the assessment of new discoveries by prospectors and mining companies. For example, in 1957 field investigations were carried out in the United Kingdom, the Union of South Africa, British Guiana, Jamaica, Sierra Leone, Bechuanaland, Ghana, Nigeria, Nyasaland, Southern Rhodesia and New Zealand.

Last year the Atomic Energy Division of the Geological Survey undertook an airborne radiometric survey of West and Central Cornwall. Several of the anomalies recorded are sufficiently marked at surface to merit pitting, trenching and exploratory drilling to prove the extent of the mineralisation underground. The area to be covered by airborne survey will be extended this year to the remainder of Cornwall, and much of Devon and Somerset. Any areas which seem to justify it will be investigated by ground parties with scintillation and Geiger-Müller counters. The Division is also examining abandoned mine workings in Cornwall, where small amounts of uranium occur. Only surface, or near-surface,

examination has hitherto been possible, but reconnaissance drilling has recently started and will continue on an increased scale during summer. The Division may later survey other areas in northern and central Wales, northern England and the southern uplands of Scotland.

The ores are examined in detail in the Division's laboratories. Radioactive specimens found in the field by the Geological Survey's own geologists, by other geological surveys, by mining companies or by private prospectors, are studied by modern techniques, some of which have been developed by members of the Division. There are over a hundred known uranium-bearing minerals and over fifty thorium-bearing minerals. Thousands of samples are normally examined annually, and research has enabled the Division to make a considerable contribution to radiogeology in published papers. Studies have been made in the fields of mineralogy and ore genesis, autoradiographic techniques, ore mineral identification and the examination of radioactive minerals by X-ray.

To mining companies and private prospectors the Division provides a free assay service for material which is considered to be radioactive. The only proviso in accepting material is that full details of locality of origin must be given, and this information is treated as confidential.

When specimens are received they are examined first by a special Geiger counter which gives a rough indication of whether the material is abnormally radioactive. If it is, representative portions of the specimens are crushed for accurate assay by radiometric techniques, and the content of uranium or thorium is estimated. Sections from the specimens are then cut by diamond saw and mounted for examination under the microscope. The sections of relatively transparent minerals are mounted on glass slides and rubbed down till they are about a thousandth of an inch thick; those of the more opaque species are examined by reflected light after polishing. Usually, the minerals comprising the specimen can be identified in this way, but it may be necessary to remove minute fragments of any undetermined mineral for examination by X-ray diffraction. The photographs obtained by this latter technique are characteristic of the particular mineral species. When radioactive minerals are exposed on special photographic emulsions they produce an image or "autoradiograph" on development. Use is made of this to locate and identify radioactive grains. Associated non-radioactive minerals in the specimens must also be identified, as the nature of these to a large extent dictates the technique that may have to be employed later in extracting the uranium or thorium. The end product of such an investigation is a report on each specimen or group of specimens submitted. This gives details of the uranium or thorium content and the nature of the minerals contributing to the radioactivity, with their grain size and distribution in relation to the associated non-radioactive minerals. Attention is also paid in such reports to specific problems.

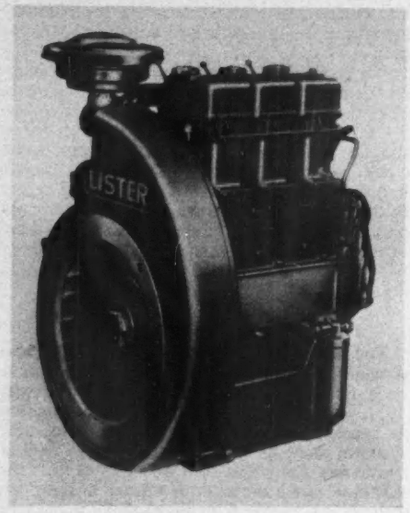
Research Reactors at Aldermaston

A LOW-ENERGY research reactor, styled "Horace," is reported now to be operating at the Atomic Weapons Research Establishment, Aldermaston, Berks. The moderator is ordinary water, so fuel enriched in the isotope U^{235} is to be employed. Various arrangements of the core will be investigated, and a number of different neutron-scattering materials is to be examined as candidates for future reflectors. This work is intended to provide data for the second reactor for A.W.R.E., called "Herald," and it is expected that results will have emerged quickly enough for "Herald" to be finished by autumn. It is to be built by the A.E.I.–John Thompson Nuclear Energy Company, Ltd., and will run at up to 5MW. A swimming-pool reactor, it is to consist of a cylindric tank made of aluminium. Various reflecting packings will be tried around the inside of the tank. The shield is to be of concrete. The fuel elements will be curved plates on the general pattern of those used in "Pluto" and "Dido" at Harwell. "Herald" will be used for various kinds of research and for the production of special isotopes.

Two Air-Cooled Diesel Engines

R. A. LISTER AND CO., Ltd. of Dursley, Gloucestershire, has recently added two ranges of air-cooled diesel engines to the power units manufactured by the company. The mark H.A. engine is a new design which is available with two or three cylinders while the mark S.L. is an extension of the L.D. units to give greater power by adopting a larger bore.

The H.A. four-stroke design has a bore and stroke of 4in by 4½in and the two-cylinder model develops 20 b.h.p. at 1800 r.p.m. or 12 b.h.p. at 1000 r.p.m., the corresponding outputs for the three-cylinder model being 30 and 18 b.h.p. respectively. The fuel consumptions at 1800 r.p.m. for the two engines are stated to be 0·43 lb and 0·41 lb per brake horsepower per hour,



Mark "HA.3" air-cooled diesel engine developing 30 b.h.p. at 1800 r.p.m.

the b.m.e.p. being 78 lb per square inch. These engines are of simple design and have a crankcase of rigid construction and a generously finned cylinder barrel and head of high grade cast iron. The aluminium alloy piston has three pressure rings and two scraper rings the top pressure ring being chromium plated and one scraper ring being placed below the gudgeon pin. A clover leaf shape of combustion chamber is formed in the piston crown and the compression ratio of 17 to 1 provides for easy starting and the engine starts easily by hand at temperatures down to minus 4 deg. Fah. The forged carbon steel connecting rods have a steel backed bronze lined small end bush and a big end bearing of pre-finished steel backed copper-lead lined pattern. Similar bearings carried the crankshaft. There is an extra cam on the camshaft to allow for the fitting of a fuel lift pump, should an engine mounted tank not be fitted, and the two valves in the cylinder are operated by aluminium alloy push rods having steel ends.

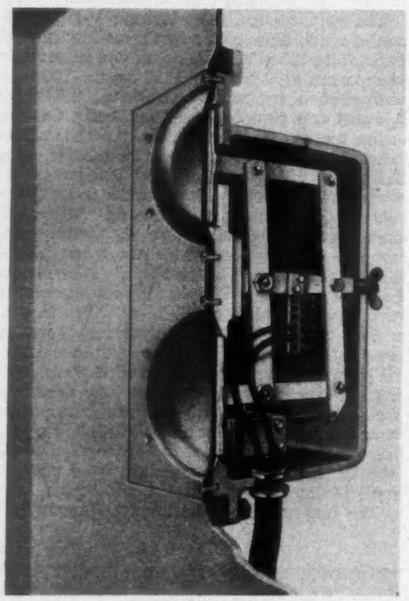
Each cylinder has its own fuel pump and fuel is delivered through a four hole injector which is finned. A gear pump circulates lubricating oil and the engine is equipped with three filters, one of full flow pattern for the lubricating oil, one for the fuel and the third for the air. A centrifugal fan bolted to the flywheel provides air at the correct pressure and baffles direct the air round the cylinders. The efficiency of the cooling has been tested by running the engine at full load for 1000 hours in a temperature of 140 deg. Fah. Close speed control is maintained by a centrifugal governor the settled variation of revolutions being within 4 per cent. The net weight of the H.A.2 and H.A.3 is given as 670 lb and 760 lb respectively and representing 33·5 lb and 25·3 lb per horsepower.

To bridge the gap between the L.D. and H.A. engines the company has introduced the S.L. models which have a bore of 3 $\frac{7}{16}$in by 3½in stroke and develop 4·25 b.h.p. per cylinder at 1800 r.p.m. or 2·4 b.h.p. per cylinder at 1000 r.p.m. The b.m.e.p. is 67 lb per square inch at 1800 r.p.m. and the fuel consumption 0·54 lb per brake horsepower per hour for the single-cylinder engine and 0·53 lb for the two- and three-cylinder units. The basic differences between the S.L. and the L.D. engines, apart from the bigger bore of the S.L., are the piston, cylinder barrel and connecting rods. A closed toroidal combustion chamber is formed in the crown of the aluminium alloy piston which has piston rings arranged similarly to the H.A. engines. Fuel is delivered from a cam operated pump through a single hole pintle pattern nozzle. A pressure lubricating plunger pump is fitted in the wet sump and a reduction gear is built integral so that either half or full engine speed is available.

Double-Diaphragm Level Indicator

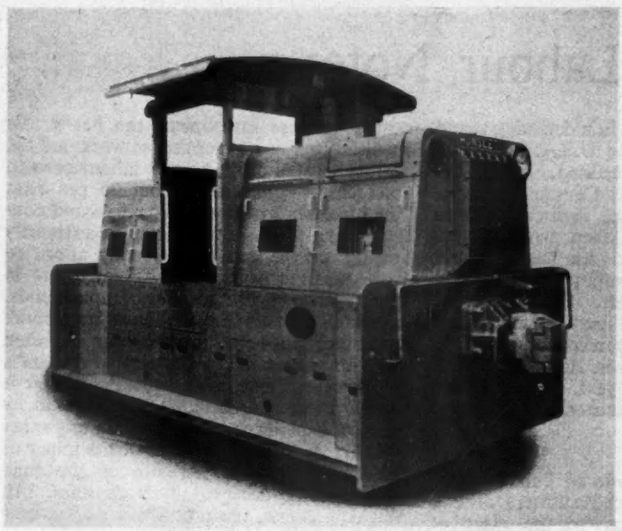
A LEVEL indicator particularly suitable for fitting in silos used for the storage of powders, granular or flaked materials and supplied by a pneumatic conveyor system, has been developed by Blaw Knox, Ltd., 94, Brompton Road, London, S.W.3. In such silos a difficulty experienced with level indicators is the build-up of air pressure above the material and the dense dust created during re-charging, which can cause undue actuation of an indicator or adversely affect its mechanism. The general construction and method of fitting one of the new indicators, which are also suitable for liquid level control in vessels, can be seen in the cut-away photograph we reproduce.

Two spaced diaphragms set one above the other in the wall of the silo actuate arms at the rear. These arms are coupled to a stabilising beam system incorporating micro-switches. When

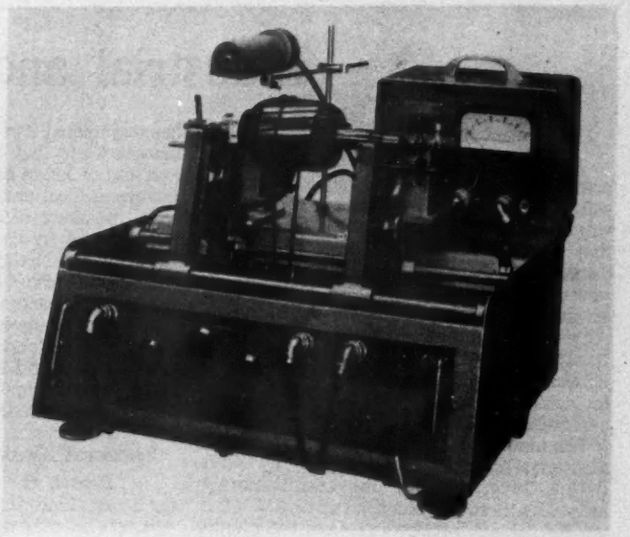


Level indicator with lower diaphragm deflected inwards to give warning or stop the feed when covered by the material stored in the silo

the level of the material in the silo falls below the lower diaphragm, as is depicted in the illustration, the return spring in the lower part of the lever system draws the lower diaphragm out. This movement actuates a micro-switch which serves to actuate a warning system or re-start a materials feed cycle. As the level of material thereafter rises in the silo its weight deflects the lower diaphragm which rocks the beam and a second micro-switch is actuated. This second switch can be arranged to stop material feed or actuate a warning device as required. It will be appreciated that the upper diaphragm through its arm imparts a balancing effect to the beam system to compensate for any build-up of air pressure above the level of the material, and ensures that only the weight of material—not air pressure—deflects the lower control diaphragm.



Diesel hydraulic industrial shunting locomotive



Direct reading dynamic balancing machine

71 h.p. Shunting Locomotive

WE illustrate above a new light industrial diesel shunting locomotive known as the "Yardmaster," being made by the Hunslet Engine Company, Ltd., Leeds. An interesting point in the construction of this locomotive is the wide field of movement the driver has whilst maintaining complete control of the locomotive. He can either drive from the usual seated positions at both sides of the cab or handle the controls when standing on the shunting platforms on either side of the locomotive.

The locomotive is powered by either a Gardener "4LW" or a Dorman "4LB" water-cooled diesel engine developing 71 b.h.p. at 1700 r.p.m. In full working order one version of the locomotive weighs 15 tons and its maximum tractive effort in first gear is 10,200 lb; in a second version, weighing 13 tons in working order the maximum tractive effort is 8800 lb.

The engine is coupled through "Layrub" couplings to a "Hunslet" single-stage torque converter built as a single assembly with a two-speed, constant-mesh gearbox. A gear selector lever operates a hydraulic control valve which directs oil pressure to the required gear clutch, it being unnecessary for the driver to synchronise the shaft speeds. In first gear the top speed of the locomotive is 5 m.p.h. and in second gear 10 m.p.h.

Dynamic Balancing Machine

A DYNAMIC balancing machine now being made by Giesler, Ltd., River Place, Essex Road, London, N.1, and illustrated above, is suitable for balancing rotors, armatures, runners, &c., weighing from 1 oz to 30 lb, up to 20in between centres and 16in diameter. The machine is fitted with a ¼ h.p., 1440 r.p.m. electric motor and the test rotor can be driven through a belt at balancing speeds from 350 to 2000 r.p.m.

The test rotor is placed upon flexibly mounted cradles which are supplied with interchangeable bearing shaft adaptor supports which can be selected in accordance with the size and weight of the rotor. These bearing supports are coupled to transducers which are sensitive to motion in the horizontal plane. When an unbalanced rotor is rotated it sets up vibrations in the system and electrical signals given through the transducers are transmitted to a display unit. These signals are amplified in two separate channels. One of these channels terminates at a pointer indicator which shows the amount of unbalance in the rotor. The scale of this indicator enables the operator to read directly the amount of compensation weight required in one or both planes.

The second channel actuates a stroboscope which flashes each time the unbalanced mass passes a given point. A numbered tape can be stuck round the rotor and the position of the out-of-balance is ascertained by noting the number on the tape which is illuminated by the flash as the rotor revolves. As unbalance is usually corrected in two planes, a control switch is provided by which either the left or the right-hand position is selected. Readings obtained from one plane of correction are independent to those set up in the other plane.

The makers point out that the electronic equipment is arranged to ensure consistent stroboscopic indication over a wide range of speeds. In addition to detecting and correcting both static, or single-plane, and dynamic, or two-plane, unbalance, the machine deals with all amplitude variations. Unbalance weight of any amount is automatically registered and the sensitivity of the machine can be set to any desired limit of accuracy. If required, the scale showing the amount of unbalance can be calibrated to show drilling depth, brass insert size, or length of solder strip required for balancing a rotor or other part. A band-pass filter which is fitted eliminates extraneous vibrations above 40 c/s and below 3 c/s.

Second Circuit in Vancouver Submarine Power Link

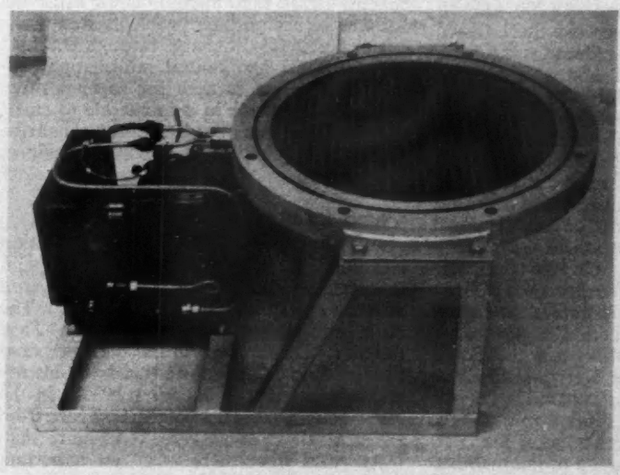
A SECOND circuit in the 138kV submarine power cable link between Vancouver Island and the mainland of British Columbia* is now in commission. Like its predecessor, this cable was manufactured, laid and tested for the British Columbia Electric Company by the B.I.C.C. group of companies, using H.M.T.S. "Monarch" to transport the cable from Trafford Park and lay it. The capacity of the two circuits is now 250MW and the total length of cable is 133 miles. In this single-core, gas-pressure cable, the 0·35 square inch conductor consists of a spiral steel duct over which are applied two layers of copper wires and a conducting screen of three impregnated, metallised paper tapes. The dielectric consists of pre-impregnated paper tapes and is screened with copper tape. The lead alloy sheath is reinforced by tin-coated bronze tapes and protected by an application of vulcanised rubber, followed by a jute yarn bedding, a single layer of galvanised steel wire armouring, and two bituminised layers of jute yarn, making an overall diameter of nearly 4in.

* THE ENGINEER, May 3, 1957

Baffles for Vacuum Pump Systems

A NOTE received from Edwards High Vacuum, Ltd., Manor Royal, Crawley, Sussex, points out the importance of maintaining an optically clean vacuum system when high vacuum diffusion pumps are mounted on particle accelerators in atomic plants. One of this firm's recent developments to prevent contamination in such a system by the pump operating fluid is in the form of special baffles cooled by a refrigerant. In this device a series of chevron shaped baffle plates are cooled to sub-zero temperatures, and a typical unit is illustrated herewith.

This particular model is suitable for mounting above a 24in fractionating oil diffusion pump, which has an unbaffled pumping speed of 12,000 litres per second and can attain a final vacuum of 5×10^{-7}mm Hg. The baffle unit is complete with its mechanical refrigerator and supporting framework ready for installation. Other models of baffles are made to suit the firm's smaller pumps and for this work on particle accelerators a series of gate valves and butterfly valves have been designed for control purposes. Each chevron baffle and valve assembly is arranged to occupy the smallest possible depth as space restrictions present a problem when mounting pumps in the complicated vacuum systems concerned.



Chevron baffle, complete with supporting framework and hermetically sealed refrigerating system

Industrial and Labour Notes

Employment and Unemployment

At the end of May, the number of people in civil employment in Great Britain was 23,052,000 (15,292,000 men and 7,760,000 women). This figure was much the same as that returned for the end of April, though during May there was some change in manpower distribution. There was, for example, an addition of 19,000 to the number employed in building and contracting; in transport the number of people employed increased by 3000 and in professional, financial and miscellaneous services there was an addition of 28,000.

The number of people employed in mining and quarrying, however, dropped by 4000 during May, and in the manufacturing industries there was a decline of 43,000 in the various labour forces, the end of the month total being 9,160,000, compared with 9,278,000 at the end of May last year. There was a further fall of 15,000 during May in the number engaged in the engineering, metal goods and precision instruments group and a drop of 3000 in the number employed in vehicle building.

The latest unemployment figures issued by the Ministry of Labour relate to June 16 when the number of people registered as out of work was 429,257. This was 18,299 fewer than a month earlier and represented 2 per cent of the total working population. The number of wholly unemployed was 367,970 and 61,287 were described as temporarily stopped. In the week ended May 24, the Ministry says, there were 217,000 operatives in the manufacturing industries who were on short time; this was 52,000 more than a month earlier. In the same week, there were 1,292,000 in the manufacturing industries who were working overtime, which was 216,000 fewer than a year ago. In the five weeks ended June 11, the employment exchanges filled 151,000 vacancies, the number of vacancies notified but still unfilled at that date being 213,000; that was 5000 more than in May.

Iron and Steel

There was a further decline in iron and steel production during June. Pig iron production averaged 243,200 tons a week, compared with 249,600 tons in May and 274,600 tons in June last year. Steel output in June was 373,600 tons a week, compared with 379,000 tons in May, and 418,700 tons in June last year. The Iron and Steel Board says that producers have reduced still further their stocks of finished and semi-finished steel which accounts for about half the decline in production compared with a year ago. But deliveries both to the home and export trade continue at a lower level than at this time last year. In the case of the home trade the reduction is due partly to a fall in the demand for steel for constructional purposes and partly to a fall in users' holdings of finished steel. In the first five months of this year, steel exports were 13 per cent less and home deliveries 3 per cent less than in the comparable period of last year.

About steel exports this year, the Board says that the decline has been principally in sheet, tinplate and light sections. On the other hand, exports of some forms of tube have been higher. Another point made by the Board concerns the trend of international trade in steel products from the beginning of 1957 up to the end of the first quarter of this year. Over that period, the United Kingdom has maintained its share in a declining world market while that of the U.S.A. has fallen and that of Japan has increased. Among the European Coal and Steel Community countries, the share of France and Germany in international trade has fallen, while that of Italy and the Netherlands has increased and trade within the Community has expanded relatively to external trade. Excluding trade within the Community itself, exports from E.C.S.C. countries accounted for about 55 per cent of world trade in steel products in the last quarter of last year, compared with 58 per cent in the first quarter.

Sponsored Research

Report, the occasional bulletin from the Sondes Place Research Institute, Dorking, devotes its current issue to the place of sponsored research in the organisation of applied research in this country—"if indeed 'organisation' is the right description for a complex of completely unco-ordinated efforts." It reviews the main agencies for such work, remarking that the forty-seven research associations, each dealing with the problems of a particular industry, "employ more than 4000 scientists and technicians and their annual expenditure is more than £4,000,000." The role of the consultant is considered—the Institute developed from a consulting and chemical engineering practice—and it is remarked that "consultants have long played an important part in the nation's economy and they have an even bigger part to play in the future if only they can be persuaded that the complexity of modern technology demands both specialisation and collaboration. Consultants are apt to be individualists. Numerous unsuccessful attempts have been made to set up an active organisation to look after the interests of consultants and to provide an effective clearing-house for information on consulting services. This would be of immense benefit, not only to consultants themselves but also to industry."

There are a comparatively small number of organisations, such as Engineering Research and Application at Dunstable, the Fulmer Research Institute at Stoke Poges, and the S.P.R.I., carrying out sponsored research in Great Britain, and the general experience has been that small firms sponsor a negligible amount of their work. The bulletin states that many "small firms do not seek advice on their problems even when it is available free of charge through D.S.I.R. establishments and official information services. . . . There is need for some positive action from outside to demonstrate to small firms that research or at least technical advice can have a value for them in pounds, shillings and pence."

Steel Industry's Labour Record

The British Iron and Steel Federation is issuing a series of pamphlets which explain the organisation and operation of the iron and steel industry in this country. The latest in this series, entitled *The Steel Industry's Labour Record*, has been prepared by Mr. Eric Wigham. It traces the history and development of labour relations in the steel industry, emphasising that, apart from the general strike in 1926, it is more than forty years since there was "an important conflict involving production workers."

One characteristic inherent in the iron and steel industry, the pamphlet says, is the high cost of capital investment, the heavy loss involved in any interruption of work and the relatively small proportion of labour costs to total costs—somewhere about 25 per cent. The incentive to the employer to avoid conflict, Mr. Wigham suggests, is extremely strong, and he can more readily afford to make small concessions than employers in other industries. Indeed, the pamphlet adds, in recent years difficulties have been more apt to arise through unwise concessions than through unreasoning resistance to demands. On the men's side, the productive worker is always conscious that the skill acquired by years of experience is of no use in any other industry, any more than that of the miner or the engine driver. Because of the rigid seniority rule accepted by both sides, Mr. Wigham asserts, the productive worker cannot hope to put his skill to much use in another iron and steel firm. His present and future are bound up with the firm for which he works; the incentive to avoid strife is no less great for him than for his employer. But, it is claimed, perhaps the most outstanding achievement of the British iron and steel industry in labour relations has been the acceptance of national organisations on both sides and their adjustment to the particular needs and traditions of individual firms and sections of the industry.

Coal

On Monday, the House of Commons "took note" of the report from the Select Committee on Nationalised Industries and of the annual report of the National Coal Board for 1957. The necessary motion was proposed by the Parliamentary Secretary to the Ministry of Power, Sir Ian Horobin.

Sir Ian surveyed the coal situation, dealing in particular with the continuing decline in the home demand for coal. The fall in demand between the first half of last year and this, he said, was equivalent to about 3,000,000 tons, and exports had also "fallen very seriously." But, Sir Ian asserted, industrial production had not fallen. Both industrial production and total energy consumption compared with 1956 and 1958 were approximately the same. What had happened was that the consumption of oil over those two periods had greatly increased and had been roughly equivalent to the fall in the demand for coal. During his speech, Sir Ian announced that the allocation basis on which industrial coal had been supplied was to be ended.

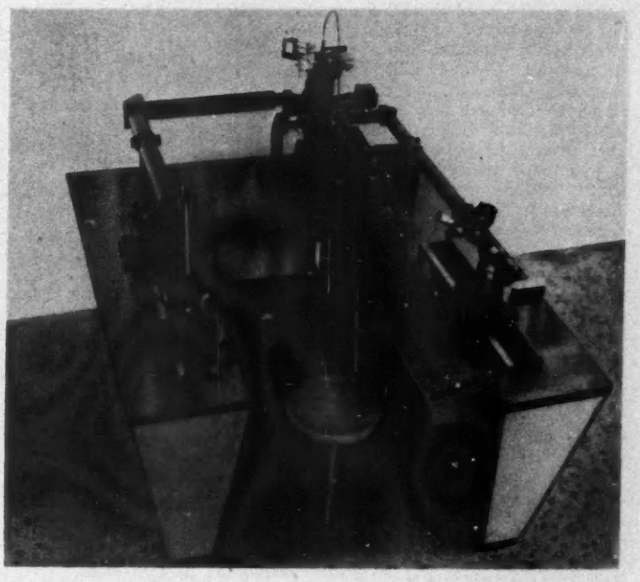
European Market Research

This week an announcement has been made about the formation of a British company, Analytical European Surveys, Ltd., the intention of which is to undertake scientific and detailed research of all aspects of marketing in European countries. It is an associate of an existing organisation, Analyses Economiques et Sociales (A.E.S.) of Lausanne. The headquarters of the British company are at 74a, Regent Street, London, W.1. The company says that it employs operational research methods, by which there can be found "the most efficient way of resolving a particular problem." By applying modern analytical techniques to the vast amount of statistical data continually being produced in all countries, the company's aim is to provide firm grounds for individual manufacturing, marketing or investment decisions.

Twelfth Achema Congress and Exhibition

No. II—(*Continued from page 72, July 11*)

The twelfth Achema Congress and Exhibition of Chemical Apparatus was held in Frankfurt-on-Main from May 31 until June 8, in conjunction with this year's Congress of the European Federation of Chemical Engineering, the Second Corrosion Congress, and other important meetings. The Achema (Ausstellungstagung für Chemisches Apparatewesen: "exhibition-congress for chemical apparatus") which is now held at three-yearly intervals has established itself as perhaps the most important event of its kind in the field of chemical technology. It seeks to bring into contact, on an international basis, the makers and users of chemical equipment, by means of lectures, discussions, demonstrations, and the exhibition itself. Seen here is a metallurgical microscope, for radio-active specimens, which allows remote observation and control.



Chemical Processes.—Speaking about the effect of oxygen on the polymerisations of chains of radicals, R. Kerber, Munich, described the formation of peroxide radicals which may react either faster or more slowly with the monomers than the remaining radicals, thus slowing down or accelerating the polymerisation. F. Endter, Constance, described the catalytic formation at 1200 deg.–1300 deg. Cent. of a mixture of prussic acid and hydrogen from methane and ammonia. After washing with sulphuric acid, the hydrogen cyanide is used immediately and thus does not require storage. New processes permit conversion of 60 per cent of the dried substance of vegetable waste products, of which there exists millions of tons, into sugars and polyalcohols, with a highly active form of lignine as by-product, according to K. Schoenemann, Darmstadt. The processes employed have in parts an even wider significance. A. Baniel and Ruth Blumberg, Haifa, described a process for producing phosphoric acid from phosphatic minerals by a wet method using hydrochloric acid, a by-product or waste product of many processes, in place of sulphuric acid. G. Weiss, Frankfurt-on-Main, reported on heavy water production processes based on exchange between water and substances containing SH-groups. Investigations proved gaseous hydrogen sulphide to be superior to all other known substances with these groups, and an experimental plant was being constructed. G. Jangg, Vienna, described an amalgam process for obtaining pure manganese, free from carbon and sulphur, and its alloys with iron or copper.

Materials Technology: Glass and Plastics.—W. Jahn, Mainz, described the construction of large protective observation windows for nuclear plant, which are usually of lead silicate glass, and frequently measure 1m in thickness and the same in width. Weighing several tons, they are composed of several thicknesses. Problems arise in connection with colour, reduction of reflection and stabilisation against discoloration by the radiation. Protective coatings on glasses formed the subject of a lecture by H. Schröder, Wiesbaden; invisible inorganic films give mechanical or chemical protection, increase surface hardness and resistance to fracture and reduce the tendency to stick of hot objects (welders' goggles) or of the glass itself to other bodies (moulding of glass). J. Massinon, Louerval, discussed new methods for improving dolomite linings in steel furnaces. R. A. Osten, Wilmington, Delaware, gave a paper on the relations between molecular structure and molecular weight, and the physical properties of polytetrafluoroethylene. F. F. Jaray, Worcester, showed the importance of the shape and form of the reinforcement in high-duty glass-fibre reinforced plastics. Tests on low pressure polyethylenes, according to K. Richard, Frankfurt (M)-Hoechst, have yielded basic information about the mechanism of deformation and thus led to new possibilities of increasing the safety of operation. W. Späth, Lustadt (Palatinate), described an impact tester which, besides the energy of the blow, also indicates the maximum force. This information, it was stated, had led to some fundamental conclusions concerning the impact strength of a large number of widely differing materials.

Laboratory Techniques: Measurements.—The amount of moisture in coal (and other substances) can be determined by entrainment, by means of an improved glass apparatus with descending condenser, according to a paper by A. Blanzat, Verneuil-en-Halatte. The electrometric determination of pH under strongly acid or alkaline conditions was described by K. Schwabe, Dresden. Melting points of organic substances and crystalline polymers, as well as the flow temperatures of thermoplastics under a given load, can be found by means of fully automatic equipment due to K. Ueberreiter, Berlin-Dahlem. For finding the speed of combustion of gas turbine fuels, a miniature combustion chamber was developed at DVL by G. Spengler and H. Gemperlein, Munich. By lengthening the subsonic chamber until choking extinguishes the flame, and using a spectrograph, the reaction kinetics may be studied. O. Kratky, Graz, described an improved X-ray diffraction camera in which small angle dispersion from the edges of the window is almost completely eliminated: thus the instrument can be used to determine those dimensions of dissolved corpuscular protein molecules such as gamma-globulin, or the degree of entanglement of dissolved cellulose nitrate. J. Fischer, Frankfurt-on-Main, gave a survey of the methods and applications of modern electric titration. L. Ivanovszky, London, reviewed the physical methods for the analysis of waxes.

Measurement, Control and Automation Techniques.—The cost of control installations, now frequently amounting to 10 per cent of the total cost of the plant, or more, is to a large extent a function of their dimensions, according to K. H. Winterling, Königstein/TS., who suggested ways by which smaller instruments and systems could be designed. W. Wuest, Göttingen, spoke about the properties and design principles of Bourdon springs. A. Kreyenbuhl, Verneuil-en-Halatte, described a novel densimetric balance, one arm of which took the form of a hairpin through which passed the liquid under test. By adding a substance which reacted exothermally with one of the components of a mixture of liquids, and measuring the temperature rise, the concentration could be calculated, stated H. Krupp, Frankfurt-on-Main. K. Strobel, Erlangen, described the measurement and control of the thickness of aluminium foils and rubber during manufacture, using radioactive isotopes. H. Weissmann, Hanover, spoke about the application of programme control to chemical processes and their resulting improvement. J. Hackel, Hanover, reported on the use of analogue machines in development and project work.

Planning, Rationalisation and Standards.—A re-appraisal of the chemical engineer's training was the topic of a talk by K. Kammermeyer, Iowa, who advocated a more selective and condensed curriculum with less duplication so as to include modern developments such as nuclear science, without having to lengthen the courses. A rational system of symbols and abbreviations was suggested by N. J. Hassett, Loughborough. American, German, British, Soviet, and Hungarian symbols for measuring instruments were critically compared by I. Nagy, Budapest. The connection between the speed of a process and the size of the equipment required can be generalised, if transport phenomena play the main role, according to St. W. Churchill and R. R. White, Ann Arbor, Michigan. J. Schulze, Berlin-Charlottenburg, read a paper of which H. Kölbel and he were the joint authors, on the application to German conditions of American work concerning cost studies of plant projects. C. J. Heckmann, Leipzig, spoke about the advantages of building up special equipment from standardised sub-assemblies.

Second Congress of the European Federation of Corrosion

The European Corrosion Federation was founded in Frankfurt-on-Main at the 1953 Achema, at the suggestion of O.E.E.C., by thirty-one technical-scientific associations. The number of member associations has since increased to forty-nine in fifteen countries. The first congress was held in Paris in January, 1956, under the auspices of the Société de Chimie Industrielle.

At the plenary meeting on June 5, Professor Helmut Fischer, Karlsruhe, in his opening remarks, referred to the fact that although natural corrosion in air, water and the soil, had largely been brought under control in the last fifty years, there had arisen, owing to the accelerated technical progress during the past two decades, so many novel problems that corrosion science found it difficult to keep up with them. Many of these involved questions of great responsibility, e.g. corrosion in high-duty boilers or nuclear plant. The other main field of research involved the effects of very slight impurities, e.g. in materials for atomic reactors, or for silicon transistors. Such impurities derived from a very minor degree of corrosion of the container walls, and recognition of this fact had led to the development of processes in in which direct contact with the container wall was precluded. As a supplement to the imposing technical show at the Achema exhibition there

seemed hardly to be a more fitting theme than that of "Corrosion in Chemistry." Organised jointly by the Deutsche Bunsen-Gesellschaft für Physicalische Chemie and the Gesellschaft Deutscher Chemiker, the congress comprised six plenary lectures and some forty-eight discussion lectures. Owing to the congested time-table, several parallel meetings had to be held, so that many visitors would have to refer to printed versions of the lectures, the full text of which was to be published in the journal *Werkstoffe und Korrosion*.

In conclusion, the speaker mentioned the hopeful development of basic knowledge since the war, notably due to the increasing understanding of electrochemical thermodynamics and kinetics in which great progress had been made by K. F. Bonhoeffer (d. 1957) and his school. Already to-day the course of corrosion could, in simple cases, be predicted quantitatively. The knowledge of inhibitors had been extended to the gaseous phase, and good progress had been made with cathodic protection.

The series of plenary lectures began with a talk by Dr. G. H. Cartledge, Oak Ridge, whose subject was "Chemical and Electro-Chemical Aspects of Corrosion in the Nuclear Reactor." Complications arise on account of ionising and high energy radiation, and the lecturer dealt with the influence of such radiation on corrosion, the behaviour of fission products, and the possibility of radiation damage to protective films on metals. He concluded his talk with a review of some of the experimental work in this field.

Dr.-Ing. habil T. Marcovic, Zagreb, spoke to the theme "The Importance of Physical Soil Properties in Connection with the Reaction Mechanism of Ferrous Corrosion in the Soil." Knowledge of those properties is stated to lead, in the case of galvanically protected pipes, to savings on preliminary studies and measurements, successful indefinite use of zinc anodes, a tenfold diminution of the corrosion, the possibility of replacing protective paints by inhibitors. Pressures giving rise to near-yield stresses can be used without danger of pinhole corrosion. Another possibility, if physical properties are taken into consideration, was protection by means of artificial ventilation. The use of inhibitors in water-saturated soils was opening up very favourable prospects.

In "Investigations of Corrosion of Pressure Pipes and the Protective Measures Adopted," Professor Dr. Ch. Chappat, Lausanne, dealt with the general conditions of formation of galvanic elements which form the starting points of corrosion processes. The author illustrated his remarks by referring to the behaviour of the various metallic components of a pipe situated in a tunnel, under the influence of ground water and constant changes of temperature and ventilation. He concluded with a description of the protective measures against a moisture-saturated atmosphere which were tested, and the properties which a coating of several layers of paint must have to give lasting protection.

Dipl.-Ing. H. Cheftel, Billancourt, spoke about "The Corrosion of Tins in the Food Industry." The great variety of forms which the corrosion of tins took depended on the multiplicity of variables involved in the external and internal attack. The thickness of the tin layer and its porosity played a secondary role compared with the grade of steel, presence of depolarisers (oxygen) at the cathode (iron), and the temperature. A coat of paint increased the rate of corrosion by reducing the effective area of the tin anode. Recent research methods involved a study of the voltage-time curve and current-time of the tin-iron element. No laboratory test, however, had yet been found which was capable of taking the place of practical trials.

The plenary lectures were concluded by lectures by T. P. Hoar, Cambridge, on "Stress Corrosion of Metals and Alloys," and by U. Franck, Darmstadt, on "Corrosion and Passivity." Professor Franck emphasised that modern research had confirmed Faraday's view that passivity was due to a very thin continuous surface layer. Since the properties of these layers differed widely with different materials, it was difficult to give an all-embracing definition of the term "passivity."

Closing Ceremony

The ceremonial closing meeting of the European Congress of Chemical Engineering and of the Achema Congress, 1958, took place on June 8, 1958, and was attended by nearly 2000 persons.

The proceedings were opened by the chairman of the Dechema, Professor Karl Winnacker, Frankfurt (M) -Hoechst, who was also the president of the European Congress of Chemical Engineering. This was followed by a special lecture delivered by the president of the Commission of the European Common Market, Professor Dr. jur. Walter Hallstein, Brussels, entitled "The Political Basis of the European Common Market," in which he outlined the great potential advantages which existed for all countries taking part in the European market.

The conclusions drawn by the speaker were warmly approved by the audience, which was not surprising in view of the fact that the official closing function and the preceding meetings of this unique congress were essentially European in character.

The lecture was followed by the presentation of Achema medallions to 178 exhibitor members by the managing director of the Dechema, Senator E.h. Dr. Herbert Bretschneider, Frankfurt-on-Main. These included eight gold medallions presented for the first time to firms which had exhibited twelve times at the Achema Congress, silver Achema medallions being awarded to those which had exhibited eight times. Senator E.h. Dipl.-Ing. Heinrich Canzler, Düren, presented a cheque for DM250,000 to the Max-Buchner Research Foundation. This grant was derived from contributions for research made by the exhibitor members of the congress who subscribed DM5 per square metre of floor space, and 10 per cent of the fees paid by visiting members of the congress. The final address was delivered by Monsieur Pierre Piganiol, Paris, who affirmed that chemical engineers were well in advance of current political developments and that thanks to the European Federation of Chemical Engineering they had already come to regard themselves just as much members of the European community as subjects of their own particular countries. The Dechema was to be congratulated in having contributed much towards this happy state of affairs.

Attendance figures at the Achema Congress and of the European Congress have since been announced. Personal registrations for the whole period of the congress totalled 15,000 congress members and 4300 students from fifty-three countries, and over 80,000 technologists attended for shorter periods. About 60 per cent of the personally registered visitors came from foreign countries.

Nuclear Exhibits

Turning now to a description of some of the exhibits, we shall first of all deal with the section concerned with Nuclear Science and Technology. The theme was covered by eighteen plenary lectures and by papers followed by discussions. In addition to the products of individual firms in Germany and abroad, there was a collective show representing German scientific and technical achievements. Models of research reactors at German technical colleges were shown in the "Education and Research" section, together with particulars of the research projects under investigation. Developments in instrumentation based on nuclear technology and models of German commercial reactors were to be found in the "Technical Developments" section. A separate section of the collective show was devoted to the applications of radioactive isotopes.

AEG Allgemeine Electrizitäts-Gesellschaft, Berlin-Grunewald and Frankfurt-on-Main, showed a reactor simulator which, on the basis of an analogue computer, can simultaneously calculate and represent the dynamic behaviour of the nuclear as well as the thermal part of an atomic power station. The demonstration set up included a model of a 100MW light-water reactor (Fig. 1). The same firm also showed part of an ion accelerator, now under construction for Tübingen University. The equipment will accelerate heavy hydrogen nuclei by means of an adjustable potential of up to 200kV, which is directed into a target of tritium, resulting in the production of fast neutrons of about 14·2 MeV. The ion current at the target will be 10mA, making the installation one of the largest of its kind. The high tension is obtained by means of a transformer and silicon rectifiers, and can be adjusted between 10 and 100 per cent; at 100mA it has a residual ripple of 0·3 per cent. The high value of 200kV was chosen to have a reserve in hand, as the maximum neutron yield occurs when the heavy hydrogen ions have an energy of about 107keV. On leaving the accelerator, the ions pass through an analyser magnet and then hit the target, a rotating disc of zirconium on which the tritium is adsorbed. Special cooling is being provided.

Among the AEG-produced equipment shown was part of a battery of condensers for experiments with nuclear fission at Munich Technical University. It is known that for fusion to occur under conditions of output exceeding input, extremely high temperatures of 10,000,000 deg. to 100 million deg. Cent. are required, which one seeks to obtain by heavy electric discharges in a plasma of heavy hydrogen. With eight special condensers—the self-inductance of the whole circuit must be kept as low as possible in order to ensure a steep rise of the current—temperatures of the order of 1,000,000 deg. Cent. are stated to have been reached. The discharge

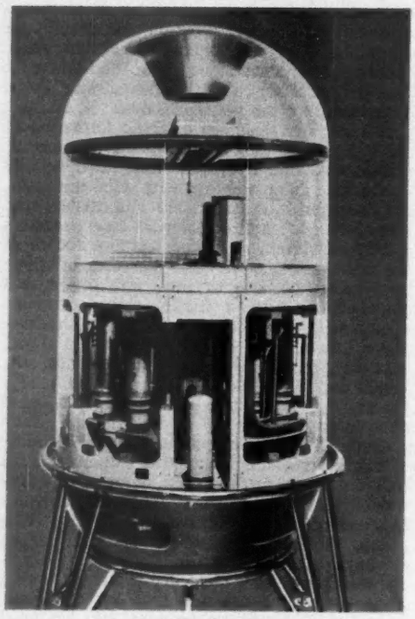


Fig. 1—Model of an AEG light-water, 100MW power reactor, with heat exchangers. The fuel elements can be changed during operation

takes place in a straight tube and is stabilised solely by the pinch effect. It is planned to enlarge the battery to forty condensers operating at 40kV and storing 160kW-seconds of energy. This will make possible discharge currents of 5,000,000A.

Heavy water (deuterium) may be obtained from naturally occurring water by various methods. A pilot plant operating with hydrogen sulphide, according to the double-temperature process, developed at the Leuna works during the war by K. H. Geib and co-workers, has been set up by Pintsch-Bamag A.G., Butzbach/Hesse, which, it is stated, will produce 500 kg D_2O per year. Production may be increased to 20 to 50 tons per annum. A model of the pilot plant was exhibited.

The German collective exhibits included models of completed or planned research reactors and isotope separation plant. Research reactors exist or are planned in Karlsruhe, Munich, Hamburg, Frankfurt, Berlin and the research centre of Nordrhein-Westfalen. The last-mentioned will contain the light-water reactor "Merlin" and a heavy-water reactor of the

DIDO design. The centre, the foundation stone of which was officially laid on June 11, will be situated in the Hambach state forest near Jülich. It will be concerned with all technical aspects of atomic science and basic physical and chemical problems as well as medical and biological research.

The reactor at Geesthacht, near Hamburg, is a 5000kW "swimming pool" design owned by the Gesellschaft für Kernenergieverwertung in Schiffbau und Schiffahrt G.m.b.H. The core of 20 per cent enriched uranium aluminium alloy is submerged in a water basin, the sides of which are formed by a large thickness of barytes concrete near the bottom and a lesser thickness of ordinary concrete higher up. The whole basin is subdivided by three waterproof gates into four compartments; these gates can be lifted out by crane when not required. Two of the compartments are used for operating the reactor, a third one for charging, and the last for setting up experiments. In the operating compartment are eight simple radiation tubes, together with two transit tubes which allow a test object to be moved quickly through the zone of maximum irradiation. In addition, there is a thermal column. The Hamburg reactor, which has a thermal output of 5MW and a neutron output of 5×10^{13} neutrons per square centimetre per second, will be used principally for research into the marine applications of nuclear power.

The "Merlin" reactor will employ 90 per cent enriched uranium with light water as a moderator. The core will be shielded by 10cm of lead and 1·8m of concrete, and will develop a thermal power of 5MW and a flux of 4×10^{13} neutrons per square centimetre per second. The reactor will be enclosed in a steel shell 30m in diameter, with pressure doors. Its construction will be under the overall direction of the AEG.

The "FR2" reactor for the Karlsruhe centre operates with natural uranium and heavy water as moderator and cooling medium. With a thermal output of 12MW, it gives a neutron flux of 3×10^{13} neutrons per square centimetre per second. Its construction is in the hands of Kernreaktor Bau- und Betriebsgesellschaft, Karlsruhe.

The nuclear chemistry section of the Berlin nuclear research centre is being built by the firms AEG, Borsig and Siemens-Schuckert, under the overall direction of Pintsch-Bamag, the reactor being supplied by the U.S.A.

Many of the latest techniques were demonstrated at the Achema by the United Kingdom Atomic Energy Authority, by means of displays and models. The isotope exhibits, covering an area of 1400 square feet, were prepared by specialists from Harwell and Amersham, and gave a comprehensive picture of this country's efforts in this important field. A few examples of what was shown may be quoted here.

Radioactive materials have been used in England to follow the movements of shingle under the combined action of waves and tidal currents, and the methods used were shown in a pictorial model. Three working models showed how radiations can be used to give an exact measurement of fluid levels for all types of vessels and liquids. Location of leaks in underground pipelines, control of insect pests, e.g. in flour, elimination of static electricity, thickness measurements and industrial radiography, were some of the other techniques shown which are already saving factories in Great Britain and elsewhere millions of pounds a year.

Some recent work on the uses of strong sources of radioactivity for food preservation and sterilisation of pharmaceutical products was exhibited, and one of the models showed an irradiation chamber at the Wantage Centre, as one possible way in which industrial products can be irradiated after being packaged.

Gamma radiation can be used to sterilise penicillin and other antibiotics which must not be subjected to high temperatures. At present these drugs are prepared under aseptic conditions which are costly to set up and maintain. The cost of production can be considerably reduced by using gamma rays to sterilise the antibiotics after they are safely packed in sealed containers. The production of vaccine by the inactivation of the virus is also possible, the control of the inactivation by radiation being more reliable, it is claimed, than chemical methods.

Sources of light which need no electricity, fuel or upkeep have been developed at Harwell. The light in these atomic lamps comes from radioactive materials which are arranged in such a way that they can cause no danger to users. They are being developed for purposes such as signalling, emergency lighting, airstrip marking, instruments, warning signs, and for use in mines. A demonstration model showed how, in a glass works, the use of a small amount of radioactive material enables a continuous check to be kept on a small quantity of sand from the time it is taken out of the sand field during the whole of the manufacturing process until it ends in the finished glassware.

By activating in the atomic pile a mixture of materials, the ability to detect certain elements (e.g. arsenic) is very greatly enhanced. The technique offers great facilities for the shortening and simplification of analytical procedure.

Whereas most of the isotopes supplied from the Harwell piles are in the form either of elements or of simple compounds, it is frequently necessary for research purposes to have an organic or sometimes complex inorganic material, some of whose atoms are radioactive. The main work of the Radiochemical Centre, Amersham, is to prepare such compounds. For medical purposes, drugs and all kinds of biological preparations such as hormones, gastric extracts, &c., are prepared or synthesised. The use of synthesised compounds with labelled atoms (carbon-14) is of value in advanced medical and chemical or biochemical research as by this means it is possible to study the exact mode of interaction of complex substances *in vivo* or *in vitro*.

Internationale Atomreaktorbau G.m.b.H., Duisburg, a jointly-owned subsidiary of Demag A.G. and Atomics International Division of North American Aviation, Inc., showed the model of a 100MW organic-moderated reactor (OMR) with steam generator and auxiliary plant. This design is stated to be the first to use an organic fluid—terphenyl—as moderator as well as heat transfer medium. Its non-corrosive nature permits the use of plain carbon steels. Primary steam temperature is 288 deg. Cent., output 620 tons per hour. A second model showed an organic-moderated reactor installation for a 38,000-ton tanker.

Laboratory mains units for a highly stabilised direct current supply for counters, photomultipliers, or scintillation counter set-ups, were shown by Ing. Albert Knott Ingenieurbüro, Munich. The "Series NSHV" has a continuously adjustable range of 500–5000V, 20mA, with a constancy better than 0·02 per cent over twenty-four hours. The output voltage can be reset again exactly, the internal resistance is low.

Farbwerke Hoechst A.G.

This year Farbwerke Hoechst A.G. for the first time displayed its products in its own pavilion, a glazed circular structure of 21m diameter and 4·8m high. Each of the twenty-five panes, which constitute the external glazing, measures 2·62m by 4·8m high by 12mm thick, weighs 800 kg and is suspended from the top edge. Many of the materials—damp-proofing layer, floor linings, water pipes, &c.—were plastics from the firm's own range of products. A small lecture room and cinema are installed.

Special products shown included plastic-impregnated carbon tiles, set in plastic, for the linings of cellulose digesters. The same plastic putty, "Asplit CN," is applied by centrifugal action to the interior of concrete pipes to render them acid-proof. For the first time coats of P.V.C. have been applied by whirl sintering. A remarkably superior appearance is achieved by "Cellit B" applied in the same way, which is stated to be equal or even superior to lacquer, and permit the achievement of a pure white as well as other colours.

For the transport of ethylene, Hoechst has been using for the last three years special four-axle tank wagons, one of which was being exhibited. These hold 26 cubic metres (13·3 tons) and by means of a vacuum insulation keep the ethylene at −100 deg. Cent. Working pressure is 0·1 atmosphere, and over a journey of 500km the pressure increase due to heat absorption is again of that order. The wagon takes forty days to reach the maximum permissible pressure of 2 atmospheres. The walls are lined with 18–20mm of polyethylene.

C. Reichert Optische Werke A.G.

The "Telatom" metallurgical microscope (shown on page 109), by C. Reichert Optische Werke Aktiengesellschaft, Vienna, makes possible the investigation of strongly radioactive samples by carrying out the observation, as well as adjustment, of the instrument and the change of specimens, from behind a lead radiation shield. Illumination and eyepiece are outside the enclosure. Coarse adjustment of the microscope, polariser and analyser, change of objective lenses and setting-up and operation of the micro hardness tester are done mechanically, while servo-motors carry out the fine adjustments.

A high-temperature stage can be used for studying cylindrical specimens at temperatures of up to 1600 deg. Cent., full temperature being reached from cold within a few minutes. An automatic exposure meter suitable for any design of microscope, covers exposure times from one-thousandth of a second to four hours, being sensitive down to intensities of 0·1 microlumen.

An ultra-microtome, according to Sitte, obtains the feed of the specimen from the expansion of a heated block of copper. The specimen carrier sits at the end of a brass rod which is flexibly attached to the copper block, and describes a D-shaped movement by hand or motor action, the downward vertical stroke being the cutting stroke against the glass knife. Thicknesses down to silver-grey interference colour are stated to be consistently obtainable.

The "Zetopan" large research microscope was shown equipped with closed-circuit television which is stated to be applicable for demonstration purposes, and also capable of increasing visually imperceptible contrasts by electronic means.

Baird and Tatlock, Ltd.

The display of Baird and Tatlock, Ltd., London, was devoted entirely to its range of "Analmatic" equipment for the automation of routine chemical analysis. Applications of the system which was first introduced three years, ago, range from the full-scale "automatic laboratory" for process control, which carries out the entire analytical procedure from the acquisition of representative samples to the presentation of results on a chart and operation of alarms denoting abnormalities, to simple instruments such as a dispensing pipette unit, which adds a precise volume of reagent to large numbers of individual samples in test tubes. An example of the full automation of an entire analytical procedure from sampling to recording of results was the colorimetric analyser for the analysis of process streams from ion exchange columns used in the refining of uranium. This equipment carries out and records analyses without human intervention, monitoring up to sixteen "barren" and/or "semi-pregnant" process streams. An "excess concentration" alarm is given whenever the measured uranium concentration exceeds an adjustable preset limit.

An absorptiometric technique is used, contemporary batch samples being taken in cyclic order from the process streams and separately treated with a suitable reagent. A reducing agent is also added to suppress interfering ions, e.g. ferric iron, and the resulting colour complexes are analysed by an absorptiometer at 3650Å.

Hartmann and Braun A.G.

A recording automatic titration apparatus was shown on the stand of Hartmann and Braun A.G., Frankfurt-on-Main. This comprises a laboratory pH-meter, dosimeter and recorder-controller for the range 1 to 13pH.

Siemens-Schuckertwerke A.G.

For use with its well-known "Elmo" vacuum pumps, Siemens-Schuckertwerke A.G., Berlin and Erlangen, has introduced an atmosphere-operated ejector to increase the effective range from about 30mm Hg down to 5mm Hg.

(*To be continued*)

Articulated Coach

THERE was demonstrated in Great Britain last week a 60ft long coach acquired by Continental Trailways, U.S.A., for their long-distance services ; at a gross weight of 22 tons, it will carry sixty-three passengers. Regarded as the longest coach in the world, it was built in Germany, where recent legislation has given great impetus to the design of articulated passenger vehicles. One hundred conventional "Golden Eagle" and "Silver Eagle" vehicles have already been supplied to this operator by Karl Kässbohrer, Fahrzeugwerke G.m.b.H., of Ulm (see Plate 13, January 10, last), and the new "Super Golden Eagle" is another example of the "Setra" construction, in which the body is the load-carrying structure. The four coaches of the trial batch are the first articulated "Setra" vehicles. The construction follows that of the "Golden Eagle" basically, but the normal rear engine installation was ruled out by the presence of the semi-trailer, and an underfloor engine is used ; the engine and gearbox are carried on a subframe attached to the structure at four points and readily removable. There being no thermo-syphon effect, it is mandatory to idle the engine for five minutes before stopping it. The driven wheels are paired and carried on a Timken-Detroit axle; it is the experience of the operator that, even when serving skiing resorts, road maintenance is so good that one live axle with a differential is adequate.

The remaining wheels are single and mounted on short and long wishbones, of which the lower are pivoted about the long cylindrical rubber-in-shear springs. Similar springs are mounted at each end of the driving axle and connected to the structure by arms and shackles ; no suspension dampers are used. The brake mechanism is mounted on the body, and drives the camshafts through universally jointed shafts reminiscent of the drive shafts of European cars.

A valve in one of the underfloor compartments of the trailer allows the driver to proportion the braking according to the load in the trailer ; the trailer wheels each have tyre deflation detectors, operating audible signals, low above the road. All tyres are nylon, 11·00×20 Goodrich, and all except one are of twelve-ply rating.

The foremost and rearmost wheels are steered, the former by the driver's effort through a ZF-Gemmer box and the latter by a linkage running up to the turntable and having a virtually perfect geometry as far as suspension movements are concerned. The turntable is used to carry the stewardesses' galley, and the damping provided by the steering of the rear wheels is evident in the tendency for steering movements to show between forward saloon and galley rather than galley and rear saloon. For manœuvring, particularly in reverse, it is necessary to give the driver a lock greater than that corresponding to the maximum articulation, and there is a bell to warn that that condition is being approached. The vehicle is fitted with a German combustion heater, and an American air conditioning plant will be installed on arrival in Texas ; this will have its own prime mover to allow the vehicle to be cooled when it is standing still. Diesel oil is the only fuel carried. The space below the cab floor accommodates a spare wheel ; since the operator allows passengers 300 lb of baggage free of charge, the remaining 5 cubic metres of space below the floor is divided into holds. The double doors open on a parallelogram linkage to lie along the sides in front of and behind the doorway.

In view of the adoption of this design by a United States operator, it is perhaps worthy of remark that the design is everywhere as simple as can be visualised and that there is a dearth of automatic systems, of which the one example is a pneumatic servo moving the radiator shutters to full open or full shut in response to a temperature pick-off on the engine. A dry plate clutch is used, so that fuel and brake controls must both be operated by the driver's right foot : this being so, a hand governor control is provided and it is set to give a high no-load speed, allowing down changes while braking. The brake pressure gauge shows both reservoir and motor pressures. The six-speed ZF "Media" gearbox, with electrical signalling, will engage a gear only at synchronism, so the light behind the gear indicator is arranged to be on only when selection is completed, thus advising the driver that transmission exists. A small engine speed indicator shares the road speed presentation, and in addition a red warning light appears when the governed maximum is approached. The smoothness of the gear change is entirely a function of the driver's judgment. The use of a gearbox requiring the engine speed to be increased during down changes has caused the hydraulic all-speed governor usual on Rolls-Royce engines to be replaced by a Simms mechanical unit. There is no automatic chassis lubrication, the complicated steering linkages being endowed with grease nipples.

We were present when the vehicle was driven from London to Harmondsworth, where the driver demonstrated its ease of manœuvre on the premises of the Road Research Laboratory ; the turning circle has a diameter of 82ft. By virtue of the large distance between the rear axle of the tractor and the turntable, cut-in of the trailer is not great, and the vehicle is surprisingly responsive in reverse. Particularly noteworthy was the low effort demanded of the driver in acquiring a heavy lock. The suspension seemed hard at the road speeds used in this country, and gear changes were very noticeable when riding in the trailer. The C.6 engine is positively blown, giving a rating of 275 h.p. at 2100 r.p.m., and was naturally rather noisy, but in service the windows will all be kept closed and this nuisance will be reduced. Running on Supplement II or III oil, the engine will go 5000 miles between oil changes, but removal of the head for decarbonisation is anticipated between overhauls. The engine has been modified to suit German auxiliaries, and such items as the air system anti-icer bear instructions in German. A maximum speed of about 70 m.p.h. is achieved.

The access hatches between the wheels of the front component cover the radiator, the engine and the gearbox : that behind the driving wheels covers one of the paired fuel tanks. On the rear component are hatches opening on to the air conditioning equipment and one luggage hold

International Aeronautical Congress

The first International Congress in the Aeronautical Sciences, under the auspices of International Council of the Aeronautical Sciences, is scheduled to take place in Madrid during the period September 8 to 13. The International Council of the Aeronautical Sciences was organised in 1957 by a group of aeronautical scientific societies in some twenty countries. The meeting will be under the chairmanship of Dr. Theodore von Karman, First Honorary President of ICAS. Arrangements include plenary lectures by Dr. von Karman and Ing. Pedro Blanco. A full programme of lectures on all aspects of aeronautical science has been arranged. Persons wishing to attend should apply to Dr. A. M. Ballantyne, Secretary, R.Ae.S., 4, Hamilton Place, London, W.1.

Quality Control Conference

The annual conference of the European Organisation for Quality Control, The Hague, Koninginnegracht 101, will be held this year in Essen, Western Germany, on September 10, 11 and 12. The theme of this conference will be "Consumer–Vendor Relations." The conference will deal with the general, the engineering, the statistical, the practical and the theoretical aspects involved. Pre-prints of the papers will be available in French and English. At the meetings, simultaneous translation into English, French and German will be provided. Discussion groups for each sufficiently represented language will be formed. Members of the E.O.Q.C. and participants of the I.S.I. Congress in Brussels which ends on September 8, will be entitled to attend all meetings and will receive the papers for the sum of DM.30—the fee for non-members will be DM60. The host for this conference will be the Deutsche Arbeitsgemeinschaft für Statistische Qualitätskontrolle (DASQ). All inquiries about the conference and bookings for accommodation should be addressed to : DASQ, attention Mr. P. Malinka, Rosserstrasse 15, Frankfurt-on-Main, Germany.

Linear Rolling Bearings

A range of linear ball and roller bearings for the slides of machine tools, jigs and other equipment, by the firm W. Schneeberger A.G. Maschinenfabrik Roggwil (Berne), Switzerland, is being put on the market in the United Kingdom by Engineering and Scientific Equipment, Ltd., 33, Minster Road, London, N.W.2. The bearings comprise a fixed and a moving vee-slide between which balls or rollers are inserted. Three main designs are being built, each in six sizes, viz. cageless ball bearings, with balls from ¼in to 2in diameter, bearings equipped with a cage, with ¼in to 1½in diameter balls, and crossed roller chain bearings with from 6mm to 24mm diameter rollers. For each slide a pair of tracks is required. Bearings are stated to be hardened, ground and lapped to an accuracy of 0·00001in per 2in of length. Tracks up to 900mm long are supplied. For long-stroke applications, where moving parts have a very long overhang or where the slide itself is shorter than the stroke, the maker produces an endless crossed roller chain design with the chain supported between two pulleys. The bearings are claimed to have very low starting and running coefficients of friction, and besides accuracy, good wear-resisting properties. When worn, they can quickly be replaced by a new set.

U.S.-Euratom Joint Nuclear Programme

THE proposed joint nuclear power and research programme to be undertaken by Euratom in collaboration with the United States Government and Atomic Energy Commission was submitted by President Eisenhower to the U.S. Congress on June 24 for " urgent " consideration. The major aim of this programme is the construction of large-scale atomic reactors of an installed electrical capacity of 1000MW, to be brought into operation in the Euratom countries by 1963. The programme is a two-way plan offering benefits to both sides. The Euratom countries will gain from U.S. experience and capacity in order to make a rapid start on the nuclear power development they need to meet their ever-growing shortage of energy : while the United States for its part will gain experience in Europe on large-scale atomic reactors which the lower cost of conventional power-stations in the United States would make it less economical to build in America.

This two-fold nature of the joint programme is reflected in the provisions of the Memorandum of Understanding between the U.S. and Euratom which provides, besides the power programme, whose total capital cost is estimated at 350 million dollars, a ten-year joint research and development programme, whose cost during its first five years will be a further 100 million dollars.

Power.—The Euratom Commission and the U.S. Government are jointly to establish technical standards and procedures for selection of the programme's reactor projects, which may be proposed, constructed, and operated by private or public bodies. The reactors, which must be of proven types on which research and development has been carried to an advanced stage in the U.S., are likely in the initial stage to be pressurised water or boiling water reactors using enriched uranium. It is expected that some six to eight of these reactors will be built in the various Euratom countries, their size varying from 100–150MW capacity.

Of the total capital cost of 350 million dollars, approximately 215 million dollars may be provided by the participating utilities and by other European sources of capital ; up to 135 million dollars may be provided by the United States Government in the form of long-term credits to Euratom, which will re-loan such funds for the construction of the facilities.

Supply of Fuel.—The fuel for the power programme is expected to amount to 30,000 kg of slightly enriched uranium. The U.S. Atomic Energy Commission guarantees full supply of this material for twenty years' operation at U.S. domestic prices in effect at the time of the transfer. Payment by Euratom on the principal may be deferred up to December 31, 1973, at an interest rate of 4 per cent per annum. The A.E.C. also guarantees the cost and performance of fuel elements and will provide chemical processing and related services at published U.S. domestic charges, until such time as this may be possible within the Community itself. This provision, which circumscribes the commercial risk, should prove a major incentive to Community plant operators. Plutonium resulting from the fuel cycle will be bought from Euratom by the U.S. for peaceful uses at the U.S. announced prices in effect at the time of the purchase. Public or private plant operators whose reactor projects are accepted for the programme will have full authority and responsibility for running the power stations according to a programme agreed upon. They will in addition be able to incorporate in the construction and operation of the plant any discoveries, improvements and economies made possible by the research and development programme.

Research and Development.—In addition to the power programme, the Memorandum of Understanding provides for research to be pursued in the United States and in Europe within the framework of a joint research and development programme, based on the types of reactors to be built. Its aims will be to improve reactor performance, to lower fuel cycle costs, and to deal with plutonium recycling and other relevant problems.

Established for a ten-year period, it will be financed by joint U.S.–Euratom contributions of 50,000,000 dollars each during the first five years. Funds for the second five years may be of the same order of magnitude. The A.E.C. and Euratom are to exchange information resulting from the joint programme as well as from research on the same subjects undertaken outside the joint programme, subject to mutually available patent guarantees.

Guarantees and Controls.—Euratom guarantees that fissile materials used in the framework of the joint programme will be put exclusively to peaceful uses and will not be transferred to unauthorised persons. The inspection and control system for this purpose will benefit from American technical experience, but will be the exclusive responsibility of Euratom.

Miscellaneous. — The Memorandum further provides for U.S.–Euratom co-operation on the following problems : the setting-up of an organisation for administering the programme ; the training of personnel ; and the development of joint industrial activities. In accordance with the Euratom Treaty, the Euratom Commission will work to minimise the impact of customs duties on the import of goods and materials under the programme. Existing agreements for co-operation between Euratom Member States and the U.S. Government are not modified by the joint programme, but will be subject to appropriate negotiations with a view to Euratom's assuming the rights and obligations now set forth in those agreements.

Finally, both parties recognise the necessity of working out suitable measures to secure protection against third-party liability.

Euratom's Target.—More than a year ago, the Report of the " Three Wise Men " set as a target for Euratom the installation of 15,000MW shortly before 1970. To-day it seems unlikely that this objective will actually be reached by the date laid down. But Europe has an essential interest in ensuring that the delay in reaching the target be reduced as much as possible. The joint U.S.–Euratom programme, largely in addition to existing national projects, represents a further step towards this objective. Furthermore, it may be complemented by other international agreements such as that now in course of negotiation between Euratom and the United Kingdom.

The studies conducted by the joint Euratom–U.S. working party which prepared the Memorandum of Understanding largely confirmed the cost estimates worked out by the Three Wise Men, affording an overall power cost (including capital and fuel cycle costs) in the range of 1 – 1·4 cents per kilowatt per hour.

Management Conference

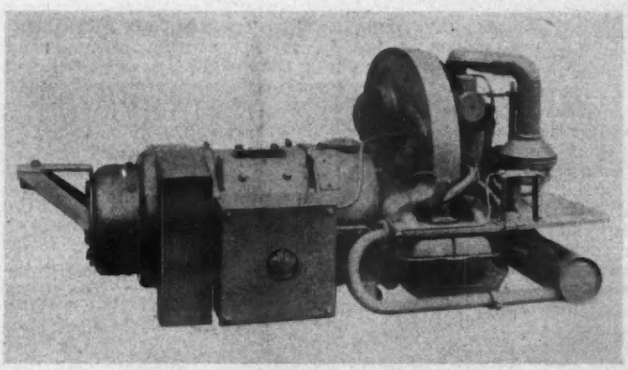
A European Management Conference will be held in Berlin from October 1 to 3, under the auspices of the German Group of the Comité International de l'Organisation Scientifique (C.I.O.S.). Its theme will be " A Free European Market—A Challenge to European Management." The meetings will be held in the new West Berlin Congress Hall. Speeches will be given by well-known industrialists and economists and will be simultaneously rendered into English, French and German. Those interested should contact the British Institute of Management (B.I.M.), Management House, 80, Fetter Lane, London, E.C.4.

Reactor for Grenoble Centre

It is announced by the Commissariat à l'Energie Atomique (C.E.A.) that the reactor " Melusine " became critical for the first time on July 1 when it began to function at low power. The reactor is the principal piece of equipment of the Centre d'Etudes Nucleaires de Grenoble, the first important research centre of the C.E.A. outside the Paris region. It is a French-built swimming-pool reactor of 1200kW, operating with enriched uranium supplied by the U.S.A. From start to finish, its construction by the industrial " Indatom " Group, in collaboration with the C.E.A., was carried through in less than a year.

Auxiliary Trolleybus Generator Set

Our illustration shows a petrol-driven generator set specially designed as an auxiliary unit for trolleybuses. It is the Model " Universal," a development of an earlier design, by the firm Imperia Aggregatebau, Düsseldorf. Powered by an industrial "VW" engine of 25 h.p. at 3000 r.p.m., the unit has a flange-mounted generator comprising a compensated d.c. generator supplying the driving motor, together with a 400V exciter machine for supplying both the generator and motor field windings. This unit enables trolleybuses of 8·5 tons tare weight to climb gradients of about 10 per cent, and to reach a speed on the level of 25km per hour. Operation is by electrical remote control from the instrument panel of the bus. The Volkswagen engine is rated for continuous full load.



Auxiliary generating set, comprising a 25 h.p. air-cooled petrol engine, d.c. generator and exciter

Navigational Improvements in the Baltic

In order to increase navigational safety, and at the same time reduce costs through rationalisation, the German Marine and Shipping Board at Kiel intends as from next year to replace its two lightships at Kiel and Flensburg by artificial islands. The third lightship, at Fehmarnbelt, is to be withdrawn when in a few years' time the danger of mines will have been removed and it will no longer be necessary to keep to a swept channel. While new lightships to replace the present ones, which were built at the turn of the century, would cost about DM.3,000,000 each, the artificial islands would cost something like DM.2,600,000 each. In addition, there is the saving in the numbers of the crew (a total of six men for a double shift, instead of twenty-six men on a lightship) ; this involves a further saving of over DM.500,000 per year. The islands will probably be solid concrete structures with a lighthouse on top. Although platforms on tubular legs are being considered their resistance to ice is a moot point. The improvements will affect the approaches to the North Sea–Baltic Canal which is used by 70,000 ships every year.

Ten Years of Transistor Progress in the United States

BY OUR AMERICAN EDITOR

No. II—(*Continued from page 77, July 11*)

The invention of the transistor, which was announced by the Bell Telephone Laboratories, of New York, in June, 1948, gave birth to a new era in electrical technology now known as "semi-conductor electronics." The following decade saw an unprecedented expansion of this new technology until to-day almost half of the American development effort in electronics is devoted to semi-conductors. Furthermore, a rapidly increasing fraction of communications and other electronics apparatus now employs semi-conductor devices rather than thermionic valves as active components. To mark the tenth anniversary of the birth of the transistor, a semi-conductor conference was held at the Bell Telephone Laboratories on June 17, and this article, based on data released during the conference, reviews some of the work of the past decade.

Circuits and Systems

FOR many years the transmission of telephone messages over very long distances has been possible only because vacuum valves were available to produce the enormous amount of amplification required. A large part of the electrical energy fed into one end of a long pair of wires is unavoidably wasted in heating the wires, and for this reason does not reach the intended destination at the other end of the pair. In a circuit from New York to Los Angeles, for example, the factor by which the signal power is reduced in this way is a number so large that its significance is hard to imagine. The number can be written approximately in a representative case as a 3 followed by 3000 zeros. To make up for this loss, the signal in such a circuit is passed through about 10,000 vacuum valves distributed in amplifiers situated at intervals along the way. Although research, development and improvements in manufacture have made these vacuum valve systems remarkably reliable and economical considering that the amplifiers are complicated and expensive to produce and maintain, there has been a continuing effort to find newer and better solutions to the transmission problem. Just ten years ago a group of staff members at the laboratories was called together and told quietly about a startling new amplifier. The discovery that amplification could be produced by a slab of crystalline germanium with two pointed wires pressed against it was of obvious potential importance in the transmission of telephone messages, so the group was given the assignment of studying this new effect and finding out what use it might have.

There was obviously no supply of transistors in these early days. Each member of the group was given a small sliver of germanium, a few words of advice, and the instruction to go back to his bench, make a transistor, and find out what it was good for. The first transistors, though they were not yet christened with this name, bore little resemblance to the devices which are so well known to-day. One of the first experimental versions resembled a mousetrap and enjoyed only a few days of popularity. It was adequate to demonstrate the phenomenon of amplification, but was not sufficiently stable to permit serious study. Within a very few weeks much better mechanical designs began to evolve and to be used for experiments. These newer versions produced electrical properties which were stable enough to be measured and used in the computation of circuit performance. Experience with such transistors inspired the rapid invention and improvement of circuits for performing all sorts of electrical functions, and the results attained were so interesting that the number of workers assigned to the problem was steadily increased.

Within a few months after the initial discovery, a transistor development group was organised. One of the functions of this group was to supply small quantities of transistors to various members of the laboratories who had use for them. This was the beginning of the sort of orderly path of development on which the commercial exploitation of a device must necessarily rest. However, the early "make-your-own" experience had disclosed a valuable avenue of quick research progress in the application of transistors in transmission. In those early days, improvements came so fast that many transistors became obsolete before they were ever connected into a circuit. Thus, several members of the original transistor group chose to meet the problem of transistor supply by continuing to make their own devices. In some isolated cases this early practice has been profitably continued to this day. The early studies undertaken in the Transmission Research Department, particularly as they related to the junction transistor, revealed some remarkable and useful properties. Among the first to be noted was the exceedingly small amount of power which the transistor required from a battery or other source to enable it to amplify small signals. Some rough calculations showed, in fact, that if a suitable treadmill and generator could be devised, a flea could easily supply the power required to operate one transistor by doing an amount of work equivalent to making one good sized jump per minute.

With respect to economy of power consumption in small signal applications, the transistor was found to be many times better than any vacuum valve. This was obviously important in portable equipment requiring batteries. To demonstrate this, the first transistorised hearing aid was built in the laboratories and was shown to provide ten times as great battery life as a comparable vacuum valve model. In this application the transistor has now completely replaced the vacuum valve. Economy of power consumption is also of vital importance in many telephone applications. In some cases, important advantages can be obtained by, in essence, replacing vacuum valves with transistors, but of far greater importance are new applications which would be completely impractical if valves were used. For example, it has never generally been practical to provide vacuum valve amplification in customers' telephone sets, principally because of the difficulty of supplying the required power over telephone lines. With the advent of the transistor this situation was radically changed. Already telephone customers with impaired hearing in America are using sets in which transistors provide the amplification required to make voices audible to them. In the research and development departments of the laboratories, there are many new telephone circuits and services under study which have a chance of being practical only because it is possible to supply power to transistors over telephone lines.

Another obviously desirable attribute of the transistor which was recognised from the very beginning was that it could be made about as small as need dictated. This fact led many to imagine a whole host of applications which were made possible principally because of the minute space into which they imagined transistor circuits could be put. It was thought, for example, that telephone repeaters could be made so small that they would fit into a cable splice. These dreams of ultra-miniaturisation have been slow in coming true for a reason which was painfully obvious to the first people who tried to make miniature transistor circuits. The vacuum valves in a telephone repeater, radio set, or television set occupy a very small fraction of the total volume. Replacing them with transistors did not make an impressive difference in the size of the equipment. In spite of this, miniaturisation was a real possibility not only because transistors could be made small, but also because they can be operated at very small voltages and currents and do not get hot as vacuum valves do. This makes it possible to use very small resistors, capacitors, transformers, and the like in transistor circuits and to pack them together very tightly. But just as transistors themselves were not available for such studies in the early days, so miniature passive components were not available. Like the transistors, they had to be made by the circuit man whose principal interest was in the electrical performance of the circuit, not in the details of the components. Present-day electronic components miniaturisation, made feasible by the transistor, is illustrated by the comparative sizes of the units shown in Fig. 5. The components include a capacitor with three miniaturised units (1), a transformer with two transistor circuit models (2), a typical vacuum valve compared with a point-contact transistor in a case (3), resistors (4), inductors (5), and three recent production models of transistors (6).

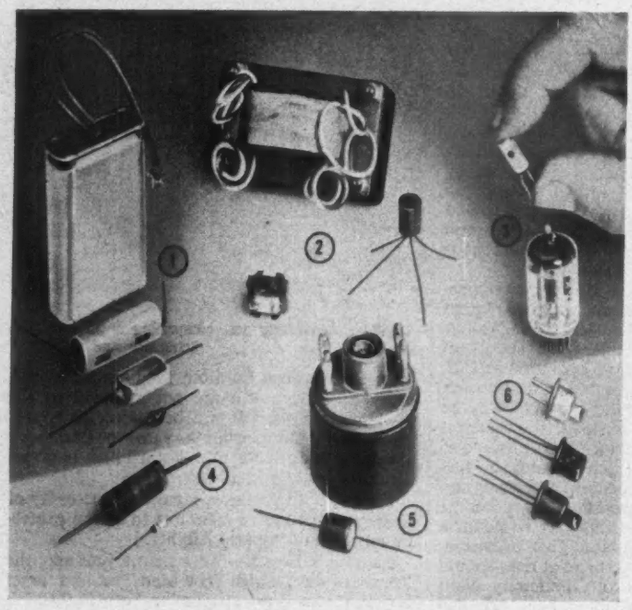


Fig. 5—Comparison of various electronic components before and after miniaturisation made possible with the transistor

Fig. 6 shows the results of an all-out effort at miniaturisation. This is a broadband amplifier only about 0·15in in diameter and 1·5in long. It contains some fifteen circuit elements including two transformers and one inductor. An example of miniaturisation in which the components have not been made quite so small is shown in Fig. 7. This package, only a little bigger than a package of cigarettes, contains a

Fig. 6—Miniature broadband amplifier containing fifteen circuit elements

seventeen-transistor radio receiver of very high performance capabilities and a battery adequate to operate the receiver eight hours a day for two weeks. It contains also the selective circuitry which would permit this receiver to be used for personal radio signalling. A customer carrying this package in his pocket could be advised, by a buzz from the receiver, that he was wanted on the telephone. In spite of the many desirable properties of the transistor, it had in the early days certain limitations which precluded its use in many important transmission applications. Not the least of these was that no transistors capable of amplifying very high frequencies or very broad bands were available. Efforts to improve this situation led to the discovery of the junction tetrode transistor and to the fabrication and use of about 2000 of these devices in experimental transmission circuits.

Another project showing the possibilities of transistored circuits is a very simple transistor

Fig. 7—Radio signalling receiver containing seventeen transistors

carrier system capable of transmitting high-quality television pictures over distances up to a few miles. This system uses a carrier frequency of 10 Mc/s and transmits a double-sideband, amplitude-modulated signal extending from 5 to 15 Mc/s. As designed, the repeaters could be spaced at 2-mile intervals on $\frac{1}{4}$in coaxial cable or at closer intervals on smaller cables. In a demonstration model, the repeaters are spaced at $\frac{1}{2}$-mile intervals in a $\frac{1}{16}$in cable, though they can be separated as much as 1 mile in this size cable by using two repeaters at each repeater site. To consider the telephone transmission plant from a somewhat broader point of view, it seems reasonable to say that the transistor arrived at a very appropriate time. In the "L3" carrier system of Bell the science of design and the art and science of manufacture of vacuum valve carrier systems had been carried to such a high degree of sophistication and perfection that it seemed hard to imagine that further refinements of this approach could yield substantial advantages.

Clearly, a completely new approach to the transmission problem was needed. In fact, such an approach had already been evolved and studied extensively in the research department. It involved converting the signal, whether it be a television picture signal or a group of voice signals, into a series of pulses and transmitting the signal in this form. At the receiving end of the line, the signal would be reconverted to the original form and delivered to the customer in such a way that he would be quite unaware that pulse transmission had been involved. This method, called Pulse Code Modulation (PCM) or simply digital transmission, offered very important advantages. The circuits had very simple jobs to do—to recognise the presence or absence of a pulse, to generate new pulses to replace those which had been somewhat degraded in transmission, and to perform other straightforward manipulations of the pulses. This could all be done with very simple circuits which did not require precise adjustment and could therefore be cheap. Furthermore, signals could be transmitted over very great distances by these techniques without suffering any of the progressive deterioration of signal quality which is inherent in other carrier systems. Any such signals were shown to be relatively insensitive to interference as compared to other forms of signal.

The principal disadvantages of this approach arise from the fact that it requires pulses to be generated and transmitted at very high rates. For example, about 750,000 pulses per second are required to transmit a bank of twelve telephone message channels, and about 70,000,000 pulses per second are required to transmit a television picture. Pulses at these high rates are attenuated very rapidly as they travel down a pair of wires or a coaxial cable and therefore have to be regenerated by repeaters which are spaced relatively close together as compared to the spacings used in older carrier systems. The fact that the repeaters are exceedingly simple and cheap is therefore partially offset by the fact that more of them are required. Studies of PCM systems using vacuum valve repeaters showed that the cost of supplying power to the large number of vacuum valves required was so great as to make the system unattractive in all but a few special cases.

A specific PCM system now approaching the final stage of development in the laboratories uses solid-state devices throughout and provides twenty-four voice channels on two cable pairs—a 12 : 1 gain in capacity. Transmission on each pair is in one direction only. Signalling as well as voice will be transmitted if this proves desirable. At the terminal, which is illustrated in Fig. 9, the portion individual to each voice channel consists essentially of a hybrid coil, simple diode and transistor circuits serving as transmitting and receiving gates and gain elements, and small low-pass filters. Somewhat similar equipment, but of an even simpler nature since the basic information is digital, is used for signalling. The rest of the equipment is common to twenty-four channels. At the talker's end, an electronic "commutator" opens the gate of each channel and measures the instantaneous speech intensity 8000 times per second. The measured sample is encoded into a

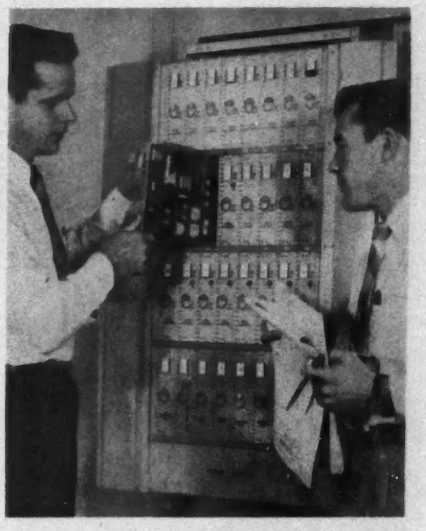


Fig. 9—Pulse code modulation terminal providing twenty-four voice channels consisting of transistor circuits

7-digit binary code representing any one of 128 speech intensities. An eighth digit is added for signalling, and, at every complete turn of the "commutator," a single framing or synchronising pulse is added. At the receiving end, the 7-digit signal is decoded, a pulse is created reproducing the intensity of the one measured at the sending end, and this pulse is injected at the right time through the receiving gate. From these pulses, the low-pass filter in the receiving arm produces a continuous speech signal that, for all practical purposes, duplicates the one sent. Compandor features are included in the common sending and receiving equipment. The cable inserts both attenuation and distortion in the pulses, so that repeaters are necessary. Here, another advantage of PCM is realised. Since the signals are in coded form, as long as they can be recognised at all, they can be freshly reconstituted or regenerated in the repeater in substantially perfect form as to pulse shape and spacing. The transistor circuit for accomplishing this, though quite subtle in design, is simple and small, and suitable for location in manholes in

Fig. 8—Comparison between vacuum valve version (left) and transistor version (right) of regenerative repeater unit

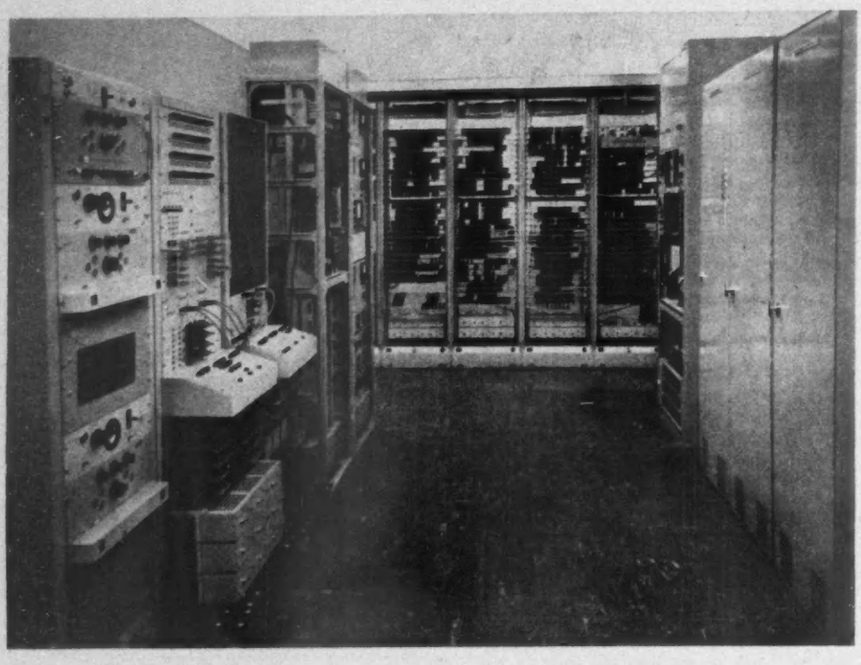


Fig. 10—Electronic switching system with switching network and barrier-grid store memory at left, central control section in rear and flying-spot store at right

enclosures similar to loading-coil cases. Because of the high pulse rates—in excess of 1,500,000 per second—loading coils must be removed. The system design has been adapted to existing manhole intervals, and repeaters will be spaced at an average of 6000ft. Power for the repeaters will be transmitted over the cable pair from the central office. A field experiment is now in progress. The amount of apparatus in the PCM system is substantially less than in a frequency-division system that would do the same job. Consequently, the lower initial cost, floor space and heat dissipation seem likely to generate extensive application in the trunk telephone lines.

The advent of the transistor, and particularly of transistors capable of very rapid operation—first the tetrodes, and later the even better diffused-base transistors—makes digital transmission systems look exceedingly attractive for a great many kinds of application in the Bell System. A comparison of the two repeaters illustrated in Fig. 8 shows why this is so. The larger unit is a pair of experimental vacuum valve repeaters designed for regenerating pulses at a rate of about 750,000 pulses per second (adequate for twelve-channel voice transmission). Each of the two repeaters requires 18·5W of power. The smaller unit is an experimental regenerative repeater using diffused-base transistors specially fabricated for the purpose. It is designed for a pulse rate of 10,000,000 per second—adequate for more than 150 voice channels—and requires only 0·6W of power. Even so, the transistor repeater delivers twice as much peak pulse power to the line as does the vacuum valve model. A great many of the transistor repeaters in tandem can be powered over the same pair of wires used to carry the signal.

Much research and development needs yet to be done before digital transmission systems will find widespread use in the telephone system. For some of the installations under consideration, it will be necessary to find ways of making even faster transistors, diodes and transformers than are at present available to the transmission-research worker. Much remains to be done in finding better ways of converting signals into pulse form and back again. Methods of encoding leading to pulse sequences which are easier to transmit are being sought. Experience has indicated the value of tackling such problems experimentally at the earliest possible moment. Some important digital systems are, however, within the range of what has already been demonstrated in the laboratory, and may find their way into the telephone system in the fairly near future.

Transistor Designs

At the Bell Telephone Laboratories the first transistor structure to be developed and, therefore, logically the first to be introduced into manufacture, was the so-called "point contact" transistor. As in the original work, this structure consisted of a small wafer of germanium soldered to a metallic base, with two point contacts on the opposite surface spaced approximately 0·001in apart. The first design to go into manufacture was not sealed to exclude the atmosphere, but was rather designed into a cartridge structure. It was designated the type "A" transistor. To give high gain and good stability, it was necessary with this transistor to "form" or electrically pulse the phosphor-bronze collector point. This procedure introduced impurities and imperfections in the immediate area of the collector point in a way that made possible not only voltage amplification but current amplification as well. This forming process is by no means simple, and, even now, many aspects of the procedure are not understood from a physical point of view. The time from the first invention to manufacture was relatively short, and in 1951 the first point-contact transistors were made by the Western Electric Works at Allentown, Pennsylvania.

The first design in which the physics of operation was well understood was the grown-junction transistor. Crystals of germanium or silicon are grown from molten material by dipping a single crystal seed into the melt and gradually withdrawing it. Impurities to form base and emitter regions are introduced into the molten material as the crystal is being withdrawn. After cooling, the crystal is cut into bars about 0·020in by 0·020in in cross section and $\frac{1}{2}$in long. Contact is made by welding a fine gold wire to the base region. A variety of codes of grown-junction transistors have been made with power dissipation up to 50 milliwatts and with frequencies of operation to several megacycles per second. One of the big Bell System applications of grown-junction transistors was found in the telephone handset where there was a need for more amplification. The circuit in this application is designed for a power gain of about 20 decibels. By adding a fourth electrode and by using transistor bars of very small cross section, to reduce collector capacitance, it is possible to raise the operating frequency of the grown-junction structure to the 100 Mc/s range. Outside of the Bell System, millions of grown-junction transistors have been manufactured, mainly for use in portable radio sets where battery life may be improved by a factor of as much as ten over conventional vacuum valve receivers.

Another important structure, called the alloy transistor, is fabricated by melting impurities into the surface of a thin wafer of semi-conductor material and recrystallising the molten portions in such a fashion that junctions are created on either side of the wafer. Most alloy transistors have been made of germanium with indium as the impurity. The alloying process makes possible a major improvement over grown-junction transistors—a reduction in series resistance of the collector and emitter contacts. In most switching applications, the voltage drop across the transistor in the "on" condition must be held to a minimum. Thus, the alloy transistor is particularly suited to various types of computer and switching logic circuitry. A variety of transistor codes of this class have been developed for a number of Bell and military systems. For example, the experimental electronic switching system shown in Fig. 10 employs a pair of n-p-n and p-n-p alloy transistors with a frequency cut-off of 7 mc per second and a power dissipation of 250 milliwatts. Even in the early days it was recognised that impurities proper for the creation of p-n junctions might be diffused into the solid semi-conductor material with major advantages of dimensional control. Years of research were necessary to identify and eliminate minute amounts of undesirable impurities which diffused into the material and resulted in a loss of charge-carrier lifetime and gross changes in resistivity. By 1954, a major breakthrough in the identification and isolation of these impurities

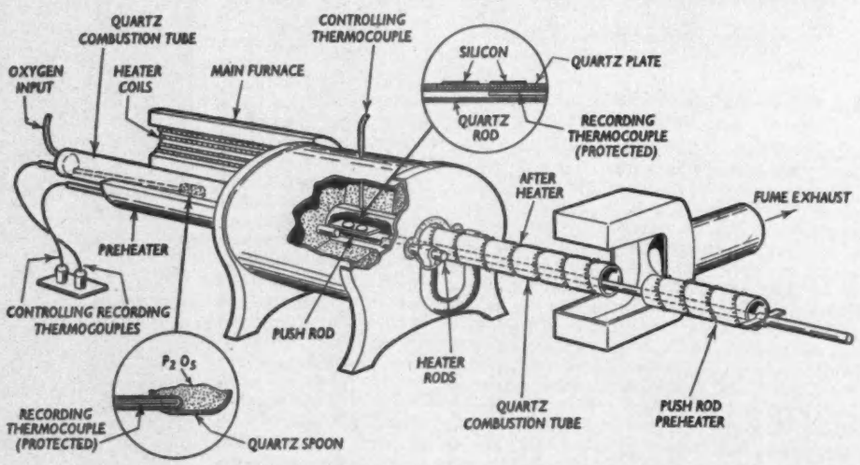


Fig. 11—Diagram of diffusion technique for introducing precise amounts of donor and acceptor impurity atoms into crystals

had made possible diffusion as a technique for creating p-n junctions in both germanium and silicon. The undesired impurities were found to be traces of various residues left on the surface after chemical etching and washing.

Several variations of the diffusion technique are used to obtain proper impurity density distribution and conductivity. However, the basic technique can be imagined from the diagram reproduced in Fig. 11. The semi-conductor material to be diffused is placed in a furnace inside a quartz or ceramic liner. The temperature of the furnace may be accurately regulated and is maintained at 100–300 deg. Cent. below the melting point of the semi-conductor. The impurities to be diffused into the semi-conductor are introduced either as a gas flowing through the furnace or by evaporation from "doping" agents within the furnace. Among the first of the devices resulting from this new technology was the Bell solar battery. Others made possible were power rectifiers and a series of voltage limiters. For example, one of the rectifiers rated at 0·5A continuous current or 10A peak, with a power dissipation of 0·5W at 65 deg. Cent., is fabricated from a wafer of silicon only 0·045in by 0·045in by 0·007in in dimension. It is interesting to note that the current density through this wafer of silicon at the peak current rating is 1000A per square inch —almost the same as that allowable by the American Underwriters' Code for copper wire used in home wiring systems.

With diffusion technology, germanium transistors have been fabricated which will amplify electrical signals at frequencies above 500 Mc/s. One kind of germanium diffused-base transistor designed as an oscillator and now in manufacture by Western Electric has a minimum rating of 50 milliwatts of 250 Mc/s power output. Units of this type have given usable power output at frequencies over 1000 Mc/s. This is ten to fifty times higher than the amplifying frequencies previously obtainable with transistors. Other units of this general type have been designed for use in the logic and switching circuits of very high-speed computing systems. The photograph reproduced in Fig. 12 shows a diffused-base germanium transistor with emitter and base stripes only 0·001in by 0·002in in size and spaced less than 0·001in apart. Electrical contact is made to these stripes by a wire bonded to the stripes and welded to the header lead-through wires. Diffused germanium transistors of this general design are now circling the earth in the "Explorer" and "Vanguard" satellites.

Diffused silicon transistors have also been developed and are being manufactured by Western Electric. Although their amplifying frequencies are somewhat lower than those of their germanium counterparts, the silicon units will find a useful place because of their operation at higher ambient temperatures and attendant reliability. Another important property of the silicon units is that when used as electronic switches they have extremely high values of impedance in the non-conducting or "off" condition. Thus, silicon transistors are being used in computer and switching applications where the very highest speeds are not required. To-day, the circuit designer has at his command a broad range of structures and characteristics. Transistors are commercially available in all of the designs mentioned above. It is not possible here to compare all of their electrical characteristics, but it is instructive to show in Fig. 13 the frequency range as a function of power dissipation presently covered by available transistors. The frequencies plotted are the alpha cut-off frequencies for the various types. For video or broadband amplifiers, the usable range would be somewhat below the cut-off frequency, while, for oscillators, one can often get usable power outputs well above the frequency cut-off.

The growth of the transistor from its birth in 1948 to its present maturity has been rapid indeed. With the critical need for electronic components in the world to-day, and with the many advantages offered by transistors, it is not surprising that such a revolution has occurred. The management of nearly every major electronic laboratory has directed teams of their most competent research and development people toward the design of these semi-conductor devices. As early as 1951, the Bell Laboratories conducted a symposium on the properties and applications of transistors. About eighteen months later, to disseminate information on device-design theory and technology more widely, the Bell Laboratories conducted a second symposium for licensees of the Western Electric Company in the semi-conductor field. Representatives of many companies attended this eight-day symposium to learn in detail the steps by which current transistors were fabricated. Also, members of the teaching staffs of many of the major universities were invited in 1952 to attend a series of lectures concerned with the theory of semi-conductors. Then, in January, 1956, a second symposium for the licensees of the Western Electric Company was conducted to bring them up to date on the advances in semi-conductor technology. A major portion of this latter symposium was spent describing the breakthrough in diffusion and the control of the properties of silicon.

In the laboratory stage there are a number of new designs which will extend the range of electrical performance of the devices presently in manufacture. One which will soon be in pilot production is the four-region switching diode. The electrical characteristics of this device are similar to those of a cold-cathode gas tube. However, the silicon device requires a great deal less power and can operate at speeds 1000 times faster than the gas tube. The active part of the unit is a silicon wafer 0·020in by 0·020in by 0·004in in size. The wafer is mounted in a ceramic or glass capsule 0·1in in diameter and 0·1in long. The impurities used in diffusing the n and p layers are phosphorus and boron. It is interesting to note that this small device requires precise control of almost every bulk and surface property known to semi-conductors. Thus, it is necessary to control accurately the density of impurities throughout the bulk material, the width of the various layers, and the density of imperfections in the bulk material, which in turn controls the lifetime of minority carriers. It is necessary to control not only the density of these imperfections but also the type of imperfections (the energy level within the forbidden gap). On the surface one must control and add impurities in such a manner that the density and type of surface states are within reasonably narrow limits. The surface must be carefully cleaned and oxidised so that the device will be electrically stable over long periods of time. In addition, the atmosphere around the device must be controlled so that there are no ions present to alter the electrical properties of the cross-point. Even with these requirements, however, the cross-point will be economical in production.

Another two-terminal device soon to be ready for manufacture is a very-high-speed silicon computer diode. By a controlled reduction of carrier lifetime, minority carrier storage has been reduced to less than 5 millimicroseconds. Other new designs of semi-conductor devices are being made in the laboratory by reducing the thickness dimension of the base layer, by reducing the spacing between electrodes, and by reducing the cross-sectional areas of the devices. In this manner, the operating frequency range of germanium and silicon transistor units can be extended by a factor of ten. Several possible designs for improving the frequency response and the power dissipation of these devices are also being explored.

(To be continued)

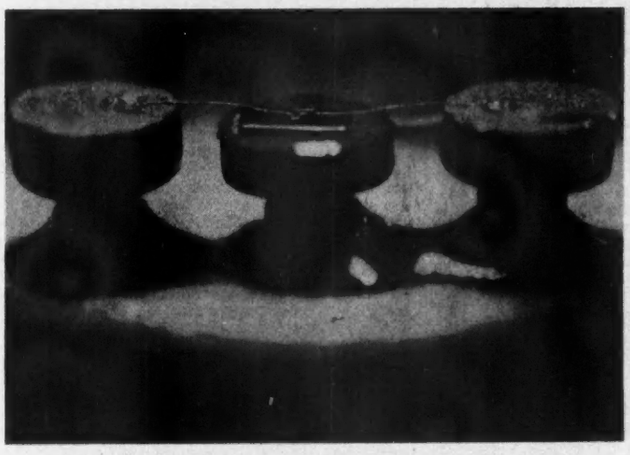


Fig. 12—Internal structure of a diffused-base germanium transistor (magnification about 40 diameters)

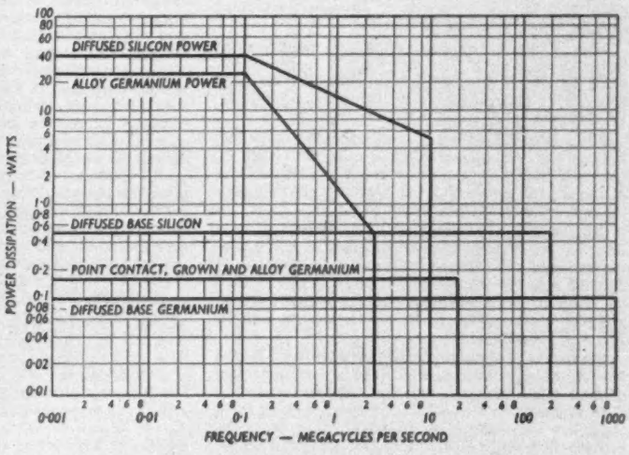


Fig. 13—Frequency of operation plotted as a function of power dissipation for various types of transistors available at present

"Package" Reactor in Alaska

A "PACKAGE" reactor, similar to the one already operating at Fort Belvoir, Virginia, U.S.A. is to be built for the U.S. Army Corps of Engineers at Fort Greely, near Fairbanks, Alaska. It is expected to be ready in 1960, and will be the first atomic power plant in that part of the world. The design and construction are to be entrusted to ALCO Products, Inc., who were responsible for the Virginian reactor. The latter was described in THE ENGINEER for August 23 and 30, 1957, pages 283 and 327, and is reported to have been generating electric energy at a rate of 2MW since April, 1957. The new example will be generally similar to the first "APPR," burning enriched uranium and being cooled by pressurised water, but it is to put out twice as much heat from a core of about the same size. Half the output of heat will be used to generate electrical energy at a rate of 1·7MW, this to meet the entire needs of the Army post at Fort Greely, described as a coldweather training station; we understand that the remaining output from the core will be used for space heating.

Personal and Business

Appointments

MR. D. G. BEDINGHAM has been appointed sales personnel manager of Remington Rand, Ltd.

MR. W. J. CARFRAE, M.I.E.E., has been appointed assistant chief electrical engineer of the British Thomson-Houston Company, Ltd.

MR. H. G. BELL, M.I.E.E., has been appointed consulting engineer, instrument and meter department, of Metropolitan-Vickers Electrical Company, Ltd.

THE UNITED KINGDOM ATOMIC ENERGY AUTHORITY has appointed Dr. N. Levin to be a deputy director of the Atomic Weapons Research Establishment.

MR. P. H. D. RYDER has been appointed chairman of Q.V.F. Glastechnik G.m.b.H., the German subsidiary company of Q.V.F., Ltd., Fenton, Stoke-on-Trent.

THE BRITISH INDIA STEAM NAVIGATION COMPANY, Ltd., has appointed Mr. John Ritchie Spiers as commodore chief engineer officer of its fleet in succession to Mr. F. T. Andrews.

Mr. W. H. EVERARD, manager of electric furnaces, Tropenas and heat treatment departments, of Edgar Allen and Co., Ltd., has been appointed secretary of the Electric Steelmakers' Guild.

MR. O. PAGE has been appointed deputy chief inspector of Samuel Fox and Co., Ltd., with effect from September 1, and has been succeeded as assistant works metallurgist (light departments) by Mr. W. Jackson.

BOWMAKER (PLANT), Ltd., announces that Mr. Glyn Jenkins has been appointed to its sales staff. Mr. H. Crewe Horobin has been appointed branch manager at the Cardiff depot, and Mr. Derek Leeks representative for the Derbyshire area.

SULZER BROS. (LONDON), Ltd., has announced that Mr. W. R. Walton, district manager in the north-western area, will relinquish his duties in that area on July 31 in order to undertake special duties relating to research and development at the Leeds Factory. He will be succeeded in the north-western area by Mr. J. H. Rutter.

BIRWELCO, Ltd., announces that Mr. A. C. Brown has been appointed deputy general manager and general sales manager, and has been succeeded as chief engineer by Mr. G. E. Corbett. Mr. J. Millward has been appointed technical manager of the furnace division, and Mr. V. D. Daft project manager to deal with sales estimating and tendering.

FERRANTI, Ltd., has announced that Mr. R. M. I. Hobill has been appointed manager of the transformer department in succession to Mr. J. E. L. Robinson who has resigned. Mr. K. R. Midner has succeeded Mr. Hobill as sales manager, transformer department. Mr. W. G. Murdoch has been promoted area manager, south-west England, and Mr. J. P. Newberry deputy area manager, London. Mr. Newberry retains his present position as chief engineer, transformer sales.

Business Announcements

KOSINE, Ltd., has moved from 104, High Holborn, London, W.C.1, to 1, Blenheim Grove, Peckham, London, S.E.15 (telephone, New Cross 2589).

THE PRESS AND SHEAR MACHINERY COMPANY, Ltd., 172–178, Victoria Road, Acton, London, W.3, has been appointed exclusive distributor in the United Kingdom for Messrs. J. Banning, Rosengartenstr. 15, Hamm (Westf.), Germany, and Messrs. A. B. Göteneds, Mek. Verkstad, Götene, Sweden.

JOHN I. THORNYCROFT AND CO., Ltd., announces the retirement of Mr. C. E. Miles, director and manager; Mr. W. H. W. Bryant, Secretary; and Mr. H. C. Bell, assistant engineer manager, of Thornycroft (Hampton) Boatyard, Ltd., and the appointment of the following as successors: Mr. H. Bish, manager; Mr. L. D. Webster, secretary, and Mr. W. L. S. Pritchett, assistant engineer manager.

Contracts

COSTAIN (WEST AFRICA), Ltd., has been awarded a contract valued at £497 470 for the construction of the Kumba–Mbonge road for the Southern Cameroons Government. This road will be more than 30 miles long and cut through uncultivated bush country. Included in the contract is the construction of twenty-six bridges—twenty-five of reinforced concrete and one, consisting of two 100ft spans in trussed steel, which crosses the River Meme. Preliminary works are in hand and work on the road, which will take 2½ years to complete, is expected to start in the dry season.

Miscellanea

LEAD DEVELOPMENT ASSOCIATION.—The Lead Development Association has recently opened new offices at 18, Adam Street, Strand, London, W.C.2. The accommodation, besides providing for the staff, has been arranged to allow the projection of films, while space has been allocated for a library and also for display purposes.

"CONQUEST OF THE ATOM."—Sir John Cockcroft introduced a coloured film with the above title at a preview in the British Council Theatre on July 10. Produced by Realist Film Unit, Ltd., for Mullard, Ltd., and the Educational Foundation for Visual Aids, it is a contribution to a series on the history of modern science. The narrative begins and ends at Calder Hall, with intermediate sequences devoted mainly to the work of Thomson, Rutherford, Chadwick and Cockcroft. Running for only twenty-two minutes, the film treats its subject in such a simplified way that it cannot be more than a supplement to sixth-form work. Copies are distributed by the Educational Foundation for Visual Aids, 33, Queen Anne Street, London, W.1.

GATE VALVES.—A development in alloy gate valve design introduced by Langley Alloys, Ltd., Langley, Bucks, is stated to improve the shut-off power of a gate valve and increase the effective working periods between maintenance work. No form of plastic, rubber or other non-metallic material is used for seating purposes in these improved valves, so that they can be used for all duties, for which the alloy is suitable without temperature or other limitations imposed by a non-metallic seating. In the improved design the wedge or gate of the valve has machined on it a series of concentric annular lands with grooves between. This "Multi-seal" feature, as it is known, is now available on all the firm's alloy gate valves of 1¼in bore and larger which are made in stainless steels and alloys, aluminium bronze, and special nickel alloys.

BABCOCK AND WILCOX COLLABORATION.—We learn that Babcock and Wilcox, Ltd., is to collaborate with The Babcock and Wilcox Company of America in work on nuclear power. The British firm has had about ten years' experience in this field. It co-operated with the U.K.A.E.A. in producing the steam-raising plant for Calder Hall and Chapelcross, and is consorting with the English Electric and Taylor Woodrow concerns in building a 500MW nuclear power station for the C.E.G.B. at Hinkley Point. The American company also has about a decade's experience in the new industry, having produced many pressure vessels and heat exchangers under the nuclear power programme. It is the principal contractor for the Indian Point station of the Consolidated Edison Company of New York, and is to supply the complete nuclear propelling plant for the merchant ship "Savannah."

SPORTS CAR DEVELOPMENT.—Small numbers of the "M.G.A." two-seater are now available in a form designated "Twin Cam" and having a twin-overhead camshaft engine and disc brakes. The engine, which has been enlarged to 1589 c.c. for competition in the 1600 c.c. International Touring Car Classification, has a gear-driven half-speed shaft in the usual place of the camshaft in a B.M.C. "B" series engine and duplex chain drive to the camshafts; the valves are inclined at 80 deg. The compression ratio is 9·9 and the gross output is 97 b.h.p. at 5000 r.p.m. and 108 b.h.p. at 6700 r.p.m.; the allowable engine speed is 7000 r.p.m., corresponding to 121 m.p.h. on the standard 4·3 axle. The sump is cast in aluminium and finned; an oil cooler is optional, as also is a radiator blind. Centre-lock disc wheels and disc brakes, both of Dunlop manufacture, are used. The "Twin Cam" specification can only be incorporated in initial manufacture, and disc brakes will not be available on the basic "M.G.A.," which was described in outline on page 626, October 28, 1955.

VISIT TO H. M. HOBSON, LTD.—A press visit made on June 18 to the works of H. M. Hobson, Ltd., at Fordhouses, Wolverhampton, showed how the firm's facilities for very accurate manufacture are now being turned to purposes outside aviation. One of the devices originally designed for aeronautical work and now being offered for process control is the "Microjet" pressure-ratio sensor, which Hobson's have been making under licence from the Solar Aircraft Company of America for about two years. This measures pressure-ratio regardless of the absolute pressures involved. The lower pressure is applied to one side of an extremely compliant diaphragm, and the higher pressure to one side of a fixed orifice. The latter opens into a chamber on the other side of the diaphragm. A tapered needle attached to the diaphragm throttles an orifice leading fluid from the chamber to a sink such as the atmosphere. In the steady state the pressures on the two sides of the diaphragm are equal, and the pressure-ratio across the fixed orifice is determined. Thus, the position of the diaphragm represents the reigning pressure-ratio (the device is described in "A New Approach to Turbojet and Ramjet Engine Control," by Wendell E. Reed, read at the Society of Automotive Engineers' Golden Anniversary Aeronautic Meeting, October 14, 1955). The company has also formed a nuclear engineering department concerned with reactor control systems (the "Dido" family of research reactors uses them), honeycombs for the preparation of radio-isotopes, &c. Master-slave manipulators for radio-active materials are also made under licence from Central Research Laboratories, Inc., U.S.A.

AIRLINER ENGINE DEVELOPMENT.—Three new versions of the "Proteus" turbo-prop engine, power plant of the Bristol "Britannia" airliner, have been announced by Bristol Aero-Engines, Ltd. Designated the 760 series, the new engines were developed from the current 750 series to give a lower fuel consumption coupled, except in one case, with higher power. The first of the new variants, known as the "Proteus" 761, incorporates modifications to the compressor which give an improvement in specific fuel consumption of nearly 3 per cent under cruising conditions, 0·486 lb per hour per pound instead of 0·499, at maximum continuous rating at 325 knots at 25,000ft. Some of these engines are already in service in the "Britannia" 312's of B.O.A.C., and in order that both 750 and 760 series engines may be operated in the same aircraft, the take-off power has been kept much the same as that of the earlier engine, 4210 total equivalent horsepower instead of 4160 h.p. However, the 761 develops maximum power at considerably lower compressor speeds and this is expected to have a beneficial effect on the already high overhaul life. The "Proteus" 762 is physically almost identical to the 761, except for a different fuel injector and a recalibrated control unit. Although cruise ratings are the same, 5 per cent more power is available for take-off, 4350 total equivalent horsepower, giving approximately 4000 lb increase in the payload capacity of a "Britannia" out of high-altitude or tropical airfields. Fuel consumption in the cruising condition is the same as for the "Proteus" 761. By means of a simple adjustment to the governor setting, the cruise power of both the "Proteus" 761 and 762 can be increased, and the engine will then become the third variant of the series—the "Proteus" 765. Take-off power of this engine is 4445 total equivalent horsepower and it will still retain the reduced specific fuel consumption of the 761.

GREAT YARMOUTH HARBOUR.—Serious undermining of the foundations at the entrance to Great Yarmouth Harbour—caused by currents and eddies scouring away the harbour bottom—has made rebuilding of the piers essential. To avoid this happening again after reconstruction, the Hydraulics Research Station, D.S.I.R., has solved the problem by altering the design of the South pierhead. Experiments on a scale model have shown that a curved pierhead will reduce the eddies and fast currents and thus prevent a recurrence of undermining to the new structures. In addition, tests with a radio-controlled model ship indicate that navigation through the harbour entrance will be less difficult. During the nineteenth century, shoaling at the harbour entrance caused a sand bar to form which obstructed navigation. This was overcome in 1872 by extending the North pierhead to encourage a natural scouring action by the discharge of water from rivers and Broads, and more particularly by the ebb and flow of the tides. But although this removed the sand bar, the scouring caused deepening of the bed over the years, beyond expectations; the pier structures were undermined and, at one point in the harbour entrance, a deep hole was scoured in the bed. In addition, decay and wave action had caused further damage and, as a result, it became necessary to rebuild both North and South piers. The problem was put recently to the Hydraulics Research Station by Coode and Partners, consultants to the Great Yarmouth Port and Haven Commissioners. At Wallingford, a model of the harbour and adjoining coastline was built to a scale of 1/120 so that existing conditions could be simulated. In this way it was possible to trace the patterns of eddies and currents which caused the undermining and it became clear that the currents would have to be diverted from their present pattern, with the object of producing an eddy-free flow of water round the South pierhead and into the Haven. Tests with a curved South pierhead showed that the tendency to undermine the structure had been eliminated. This research has solved a serious problem and led to a new design for the South pier which will cost very little more than rebuilding the existing structure

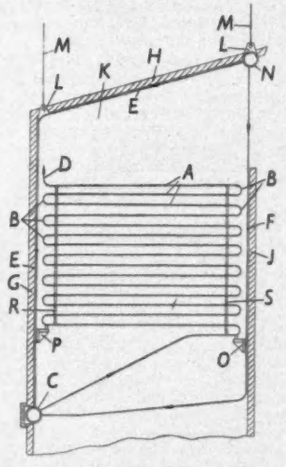
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each.

STEAM GENERATORS

796,950. December 31, 1956.—BOILER ECONOMISERS, Senior Economisers, Ltd., 11, Southampton Row, London, W.C.1. (*Inventor: Lewis Empsall Hardy.*)

The invention relates to boiler economisers embodying a number of serpentine tubes disposed in a chamber, each tube being bent or connected to form a continuous length having horizontal or substantially horizontal portions disposed one above another in a vertical plane, and arranged either to form a single group, or a number of groups spaced apart, the lower end of each tube being connected to an adjacent common header, and the upper end of each tube being connected to a common feed inlet header, with the planes containing the respective vertical rows of horizontal portions being parallel to one another.



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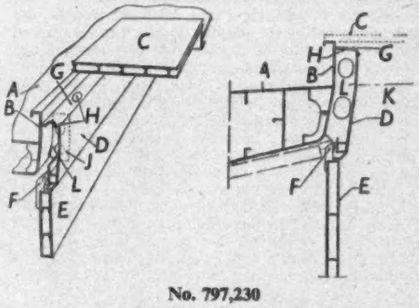
The object of the invention is to provide improved or simplified forms of such economisers. As will be seen from the drawing, there are provided a number of serpentine tubes, each comprising horizontal tube portions *A* united by ends *B* to form a single group, the horizontal portions *A* being arranged in a vertical plane parallel to the planes containing the horizontal portions in other serpentine tubes. Each tube is connected at its lower end to a header *C* and at its upper end *D* to a further header, not shown. Water-wall tubes *E* and *F* are provided in the walls *G*, *H* and *J* of a chamber *K*. The tubes *E* are supported by saddles *L* depending from straps or bars *M*, these tubes being connected at their upper ends to a header *N* and at their lower ends to the header *C*. The tubes *F* are connected at their upper and lower ends respectively to the headers *N* and *C*, and these tubes carry brackets *O* and *P* respectively, which support the tube portions *A*. The horizontal portions of each serpentine are braced by vertical plates or strips *R* and *S*. Water passes downwards from the common feed inlet header *N* above the wall *J*, by way of the tubes *E* and *F* in parallel paths to the header *C*, from which it passes up through the tubes *A* to the point *D*. The tubes *E* and *F* are preferably set into the inner faces of the top wall *H* and the side walls *G* and *J* of the chamber *K*, so as to act as supports for the walls of the chamber. Constructions of economisers embodying the invention are particularly desirable in the case of large units.—*June* 25, 1958.

MARINE ENGINEERING

797,230. February 9, 1956.—HATCHWAYS FOR SHIPS CARRYING CARGO IN BULK, Aktiebolaget Gotaverken, Gothenburg, Sweden.

According to the invention a hatchway for ships comprises two shifting bulkheads extending downwards into the hold one on each long side of the hatch coaming and two reserve holds or feeders contiguous to the hatch coaming and communicating respectively with the spaces in the hold outside the shifting bulkheads. Preferably each long side of the hatch coaming comprises two spaced vertical members projecting up above the deck, the space between the members being in open communication with the hold for the cargo and forming a reserve hold or feeder. The drawing shows an embodiment of the invention as applied to a cargo ship for the transport of grain. The hatchway provided in the deck *A* of the ship is surrounded on all sides by an outer coaming *B* adapted to be tightly closed in the usual manner by a hatch cover *C*. Inside each of the long sides of the coaming there is a vertical member *D* which extends between the short sides of the coaming and the lower end of which is formed such that shifting bulkheads *E*



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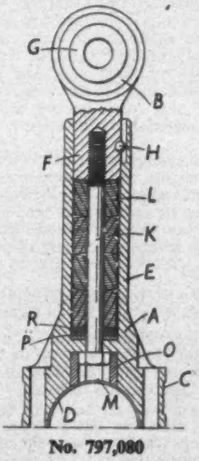
can be suspended on hinges *F*. At its upper end, the member *D* has a horizontal plate *G* which may be a bent portion of the member. The plate *G* is secured to the coaming plate *B* and provided with suitable filler openings *H* for the load. The inner member *D* does not extend upwards to the same level as the coaming plate, and, consequently, the hatch cover will tightly cover the long sides of the entire hatchway. The member *D* and the coaming plate are suitably interconnected by crosswise reinforcing members *J*. Between the two longitudinal members *D* there is obtained a large central space *K* serving as a reserve hold for the main section of the cargo space, while between each of the members *D* and the adjacent coaming plates *B* there is formed a space *L* serving as a reserve hold for the lateral sections of the cargo space. If the ship is to carry grain, the shifting bulkheads are placed in vertical positions and retained by suitable means, such as crosswise arranged truss members. The shifting bulkheads have small lateral openings, not shown, such that all sections of the cargo space can be substantially filled directly from the central part of the hatchway. The lateral sections of the cargo space and the spaces *L* in the coaming are finally filled through the openings *H*, so that a sufficient amount of cargo will be supplied into each section of the cargo space. If desired, the openings *H* may be closed by covers to prevent communication between the various sections of the cargo space through the coaming spaces after finished loading.—*June* 25, 1958.

INTERNAL COMBUSTION ENGINES

797,080. March 24, 1955—CONNECTING RODS, Benjamin William Crossley, 14, Van Dyck Avenue, New Malden, Surrey.

The invention is concerned with connecting rods for internal combustion engines. Its object is to provide a connecting rod which reduces the stresses imposed upon various parts of the engine by the rapid expansion at detonation of the fuel. As shown in the drawing the rod comprises a big end section *A*



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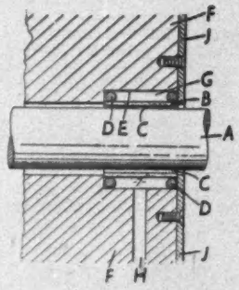
and a small end section *B*. The big end section is formed at one end with a cross-head *C* provided with the usual recess *D* for the accommodation of part of the big end bearing. The remainder of the big end section comprises a tubular portion *E* having a bore of circular cross-section. Slidably mounted in the end of the tubular portion *E* is a cylindrical portion *F* of the small end section *B*, which cylindrical portion carries a cross-head *G* adapted to receive the small end bearing. A steel ball *H* fits into a recess in the cylindrical portion *F* and into a groove inside the portion *E* so as to permit sliding while maintaining correct alignment of the cross-heads *C* and *G*. A bolt *K* passes with a working clearance through a hole in the cross-head *C* of the big end section and co-axially through the tubular portion *E* and is screwed into the cylindrical portion *F* of the small end section. Disposed within the tubular portion *E* and around the bolt *K* with a small clearance are a number of Belleville washers *L*. The washers are arranged in a number of stacks, those of one stack having their concave sides facing one direction and those of the adjacent stack having their concave sides facing in the opposite direction. The washers resiliently resist movement of the cylindrical portion *F* into the tubular portion *E* while the bolt *K* prevents movement apart of the two portions. A cavity *M* in the recess *D* of the big end section cross-head accommodates the head of the bolt *K* and a keeper *O* fits within the cavity around the bolt head. The keeper is externally and internally of hexagonal shape so that after adjustment the bolt can be locked in position by the keeper. Between the washers *L* and the end wall of the tubular portion *E* are a number of distance pieces *P* and shims *R*. Thus by adding or removing washers or shims and by adjusting the bolt, the required distance can be obtained between the big and small end centres and preloading can be effected to fine limits.—*June* 25, 1958.

BEARINGS AND SUPPORTS

796,926. August 16, 1955.—GAS LUBRICATED BEARINGS, United Kingdom Atomic Energy Authority, London. (*Inventors: Albert George Montgomery and Frank Sterry.*)

The invention relates to gas lubricated bearings. One of the major difficulties which arises in the use of such bearings is the instability of the rotor which occurs under certain conditions of working. An object of the invention is the obviation of these instabilities and in consequence the bearing clearance can be substantially larger than is normally provided i.e.; it can be of the order of 0·003in for sizes in the region of 0·75in rotor diameter. Referring to the



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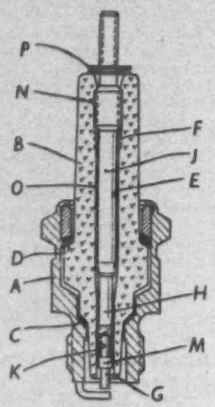
drawing, a shaft *A* is contained in a porous metal sleeve *B* with a clearance *C* between the sleeve and the shaft of the order of 0·003in. This clearance is substantially larger than those normally employed in gas bearings. The sleeve *B* has a rubber ring *D* encircling each of its ends. The sleeve with its associated rings is contained in a chamber *E* in the main body *F* of the bearing with the rings *D* in contact with the walls of the chamber. Thus the walls of the chamber, the outside of the sleeve *B* and the rings *D* define an annular shaped reservoir *G* which is provided with a gas inlet *H* passing through the body of the bearing. The sleeve is held in place by a plate *J*. During operation gas under pressure is passed via the inlet *H* to the reservoir *G* where it filters through the porous walls of the sleeve *B* into the clearance *C* and acts as a lubricant. The rubber rings make the bearings self aligning and it is found that the instabilities which usually occur do not arise.—*June* 25, 1958.

ELECTRICAL ENGINEERING

797,063. November 22, 1956.—SPARKING PLUGS, Robert Bosch G.m.b.H., 4, Breitscheidstrasse, Stuttgart, Western Germany.

The invention relates to a sparking plug having an insulator which receives a multi-part centre electrode and which is tightly clamped between two shoulders in a metal casing, the multi-part electrode being secured in an axial passage formed in the insulator. Referring to the drawing, mounted in a metal casing *A* of the sparking plug is an insulator *B*. For fixing purposes, collar-like flanges on the insulator are clamped between corresponding shoulders provided in the casing. Intermediate sealing layers of metal are provided both on the ignition end sealing seat *C* and on the connecting end insulating sealing seat *D*. In the insulator *B* there is an axial passage *E* for receiving a multi-part centre electrode. The ignition end section of the axial passage is free from projections and merges into the connecting end section, approximately at a point midway between the two insulator sealing seats, through a gradually enlarging passage section. The connecting end section of

passage *E* has an internal thread *F* for the attachment of the centre electrode. The centre electrode consists of three parts, an ignition or sparking part *G*, an intermediate part *H* and a connecting or terminal part *J*. The sparking part *G* consists of silver and has a smaller diameter than the adjacent intermediate part which is made of nickel. A blind hole *K* is formed in the end face of the intermediate part *H*



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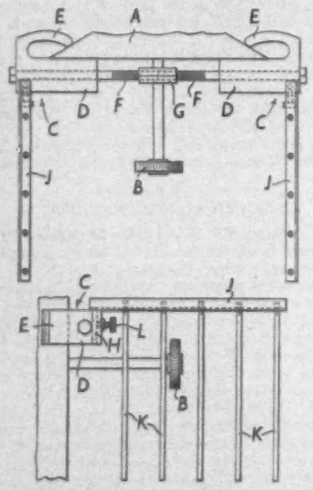
facing the ignition end of the plug, into which hole is inserted a portion of the sparking part *G* which is secured in the hole with good heat conductivity by a layer of solder applied to the closed end of the hole. The sparking part *G* carries a collar *M* which serves to cover the place of insertion of the part into the intermediate part *H*. The intermediate part is butt-welded to the connecting or terminal part *J* which consists of steel. Part *J* has an externally threaded portion *N*, which engages in the internal thread *F* of the insulator passage *E* and thus secures the centre electrode in the insulator. To reinforce the attachment and for additional sealing purposes, there is applied between the centre electrode and the insulator a layer of putty *O* which extends from the collar *M* to the thread *N*. In order to achieve the desired purpose of maintaining the centre electrode as cool as possible, the part *G* which is of good heat conductivity, extends approximately to the level of sealing seat *C* at the ignition end of the insulator, that is to say, into the zone of the insulator which is cooler owing to the discharge of heat, by way of the sealing seat, to the casing of the sparking plug.—*June* 25, 1958.

MACHINE TOOLS

796,983. September 5, 1955.—IMPROVED GUARD FOR A HORIZONTAL MILLING MACHINE, Archibald Francis Johnson, 9, Alfred Road, Acton, London, W.3.

The invention relates to a guard for a horizontal milling machine. At present, the guard for a horizontal milling machine is fitted to the steady arm, and this has the disadvantage that the steady arm, and the cutters, frequently become fouled up. Also, some forms of guards become damaged quite easily,



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and do not always give the necessary protection to the operator. In the improved guard described, the face of the column of the milling machine is indicated at *A*, and two guards constructed according to this invention are shown, one at each side of the cutter *B*. Each guard comprises a fixing bracket, consisting of a block *C* having two limbs *D* and *E*, the limb *D* lying flush against the face of the machine, and the other limb *E* being curved so as to abut against the adjacent inclined edge of the ways of the column *A*. The limb *D* of each block has a hole for receiving a bolt or spindle *F* and the threaded ends of the two bolts or spindles *F*, with right and left-hand threads, are interconnected by the adaptor *G*, which can be turned to draw the bolts axially towards one another and so force the limbs *E* of the blocks tightly against the edges of the column so that the blocks *C* are maintained in position. By slackening the adaptor *G* the guards can be adjusted for height. The corner of each block *C* has a bore which receives a pin *H* at right angles to a transverse bar *J* having a number of spaced vertical rods *K* depending from its lower edge. It is preferred to use two guards disposed one at each side of the cutter or cutters. The mounting blocks *C* may be fixed to the column at a predetermined position, or, as shown, they can be clamped to the column, so that they may be adjusted to set the guard at the required height with respect to the cutters.—*June* 25, 1958.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

MOLYBDENUM AND CHROMIUM-MOLYBDENUM LOW ALLOY STEEL ELECTRODES FOR MANUAL METAL-ARC WELDING

No. 2943 : 1958. Price 4s. 6d. The addition of three further types of electrode in the low alloy steel range and recognition of United States welding practice are noted in this revised standard. The first part of the publication specifies a method of identifying electrodes and is based on four code letters, each of which relates to a specified chemical composition of the deposited weld metal. The marking clause requires each bundle or package of electrodes to be clearly marked with eight separate items of information—the "code marking" and a certification of compliance with the standard being among them. Other subjects dealt with include size of electrode ; packing and storage, and initial and production control tests.

The second part of the standard specifies detailed test methods for chemical composition and mechanical properties.

POWER-DRIVEN TRAVELLING JIB CRANES (RAIL-MOUNTED LOW CARRIAGE TYPE)

No. 357 : 1958. Price 10s. As with the seven existing British Standards for cranes and excavators, the purpose of this revised publication is to indicate minimum constructional requirements and to ensure reliability and safety in use. It places no restrictions on the general design of cranes or on the methods employed in their construction. The standard deals with travelling jib cranes of the following types : non-shunting, free on rail ; shunting, free on rail ; portable ; and any of these types of cranes using outriggers and those with part slewing.

The method of calculating forces in steel members in the crane structure now refers to the recommendations contained in B.S. 2573 "Report on permissible stresses in crane structure," and the principle of using a factor of safety has been discharged. The original method was based on the ultimate tensile strength of the material, but now the elastic limit is the criterion.

Detailed requirements are specified for the design of the crane structure and hoisting equipment, and for brakes, electric motors, controllers and protective gear. The clause on stability has been modified and there is now only one set of coefficients. Test requirements are tabulated for easy reference.

GLOSSARY OF TERMS USED IN HIGH VACUUM TECHNOLOGY

No. 2951 : 1958. Price 7s. 6d. The purpose of this new standard glossary is to define the terms of accepted value in the many branches of science and industry where high vacuum technology has become important.

The glossary differs in detail from the complementary American standard, but every endeavour has been made to ensure that as far as possible the same term is used with the same meaning in the two countries. Where a number of terms with approximately the same meaning have come into use, those preferred have been selected for definition. Certain terms which are redundant or deprecated have been listed separately in an appendix, along with the reasons for their non-acceptance.

The glossary is arranged in sections, dealing separately with general terms, vacuum systems, pumps and pump components, manometers and gauges, leak detectors, and vacuum applications ; the last-named section contains terms relating to well-known vacuum processes, including electrical and valve manufacture. Comprehensive notes on pressure units, critical backing pressure and sensitivity definitions in leak detection are given in an appendix.

The publication also contains a list of the symbols and abbreviations used, and ends with a detailed index to the terms defined or discussed.

Launches and Trial Trips

CHAUMONT, oil tanker ; built by the Ateliers et Chantiers de France for the Société Maritime des Petroles B.P. ; length between perpendiculars 630ft 9in, breadth moulded 86ft, depth 46ft 8in, draught loaded 35ft 1in, deadweight 32,650 tons, displacement loaded 42,440 tons ; thirty cargo tanks, three 1300 tons per hour cargo pumps ; two 600kW turbine-driven generators ; one set of double reduction geared C.E.M.-Parsons turbines ; 15,200 maximum horsepower at 108 propeller revolutions per minute, 14,000 service horsepower for service speed of 16·4 knots, two Penhoët P.41 water-tube boilers supply steam at 600 lb per square inch and 850 deg. Fah. Trial, May 1.

FRANCOYSE DE GRACE, pilot boat ; built by the Chantiers et Ateliers Augustin Normand for the Société "Les Pilotes du Havre" ; length between perpendiculars 38·50m, breadth 7·40m ; depth to upper deck 6·15m, load draught 3·285m, speed 13 knots, radius of action 1750 miles, diesel-electric machinery of 1200 h.p. Launch, May 20.

IRON AGE, ore carrier ; built at Govan by Harland and Wolff, Ltd. for the Vallum Shipping Company, Ltd. ; length between perpendiculars 485ft, breadth moulded 68ft 9in, depth moulded 36ft 3in, deadweight 15,800 tons ; two large holds, six hatches one small hold forward ; three 220kW diesel-driven generators ; Harland and Wolff two-stroke, single-acting, opposed piston diesel engine, four cylinder 620mm diameter by 1870mm combined stroke, 118 r.p.m. Trial, May 22.

VIOLETTA, oil tanker ; built by the Furness Shipbuilding Company, Ltd., for Santiago Sociedad Armadova S.A., Panama ; length between perpendiculars 525ft, breadth moulded 71ft, depth moulded 39ft 3in, summer draught 30ft 6in, deadweight 18,050 tons ; twenty-seven oil cargo tanks, one cargo pump room, three 700 tons per hour turbine-driven centrifugal cargo pumps, three 150 tons per hour vertical duplex stripping pumps ; 13in diameter cargo mains, 12in diameter discharge and filling lines ; two 325kW turbo-generators, one 100kW diesel-driven generator ; one set of Richardsons, Westgarth double reduction turbines, 7300 s.h.p. at 100 propeller r.p.m., steam supplied at 450 lb per square inch and 750 deg. Fah. by two Foster-Wheeler "D" watertube boilers. Trial, May 22.

MONTMARTRE, oil tanker ; built by the Chantiers Navals de la Ciotat for the Compagnie Nationale de Navigation ; length between perpendiculars 607ft, breadth moulded 83ft 8in, depth 43ft 8in, draught loaded 33ft, displacement 38,440 tons, deadweight 30,230 tons ; two 1000 tons per hour cargo pumps, one 200kW turbine-driven generator, one 200kW diesel-driven generator; Burmeister and Wain mark VTBF 160 diesel engine. Trial, May.

VESTLAND, bulk carrier ; built by the Chantiers Reunis Loire-Normandie for Amlie ; length between perpendiculars 458ft 6in, breadth at main deck 64ft, depth to main deck 39ft 4in, draught 27ft 9in, deadweight 13,000 tons, three 200kW diesel-driven generators ; one Sulzer mark 8SD72 diesel engine, 5600 h.p. at 125 r.p.m., speed 14·5 knots. Trial, May.

YANG TSE, cargo liner ; built by the Chantiers Navals de la Ciotat, for the Messageries Maritimes ; length between perpendiculars 467ft 8in, breadth moulded 61ft 8in, depth to shelter deck 38ft 11in, draught loaded 25ft 7in, deadweight 8300 tons, full load displacement 14,079 tons ; speed 16 knots, radius 12,000 miles ; six passengers ; three complete decks, seven watertight bulkheads ; five holds, one 60-ton, one 30-ton, four 10-ton, ten 5-ton derricks, electric winches ; three 250kW diesel-driven generators ; Schneider-Burmeister and Wain single-acting, two stroke diesel engine, 8400 h.p. at 115 r.p.m. Trial, May.

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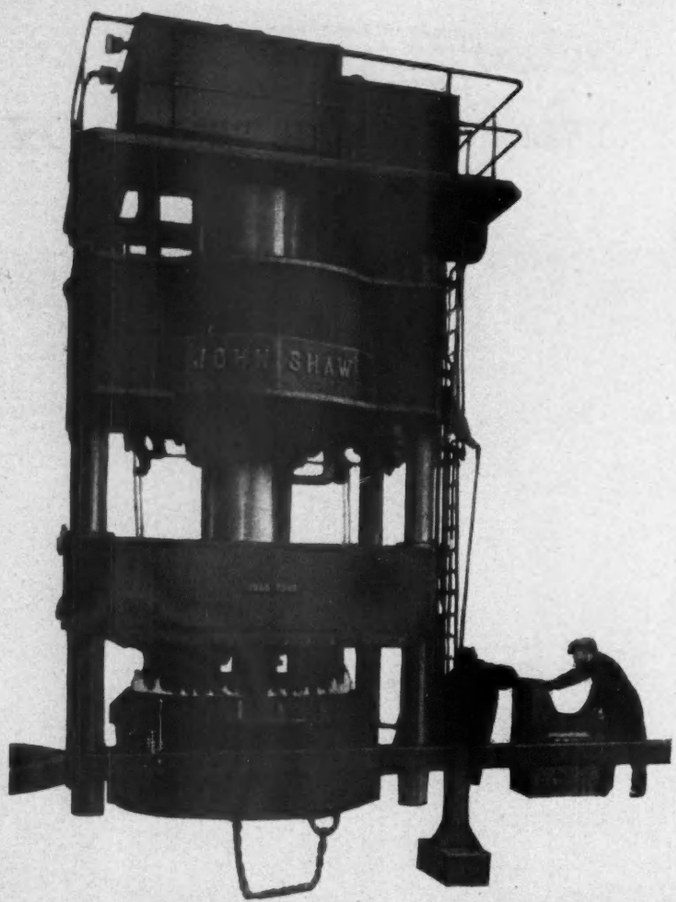

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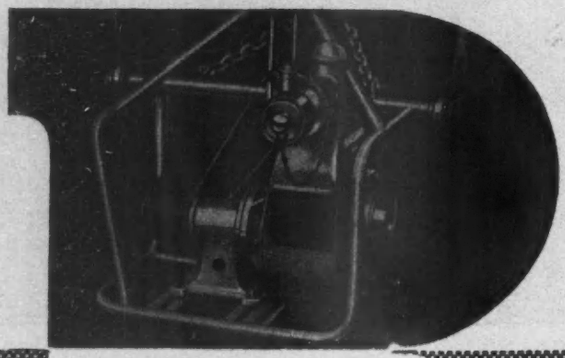

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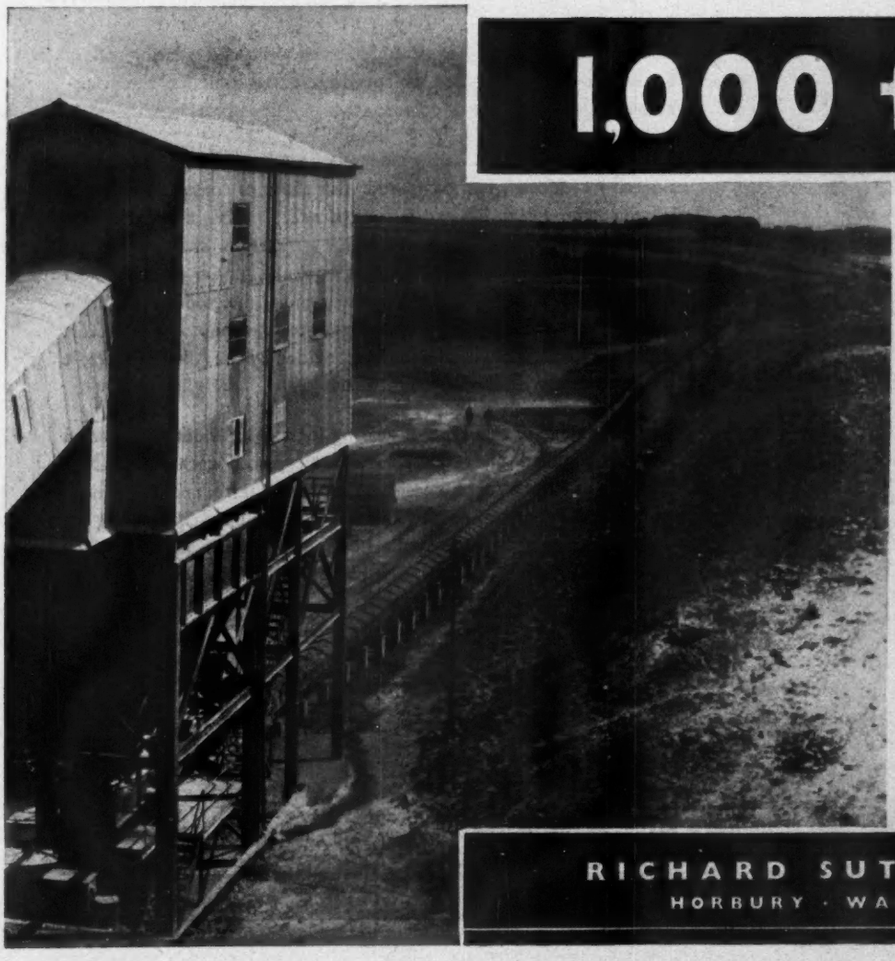

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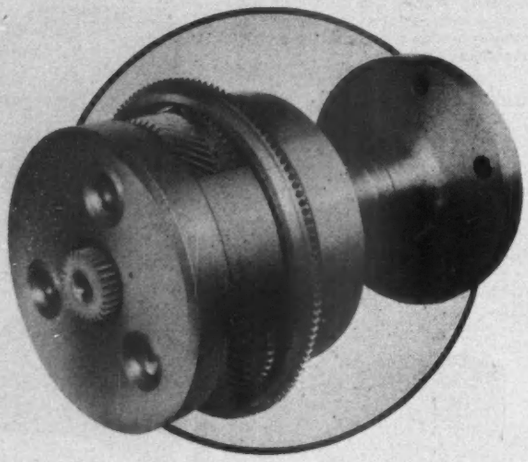

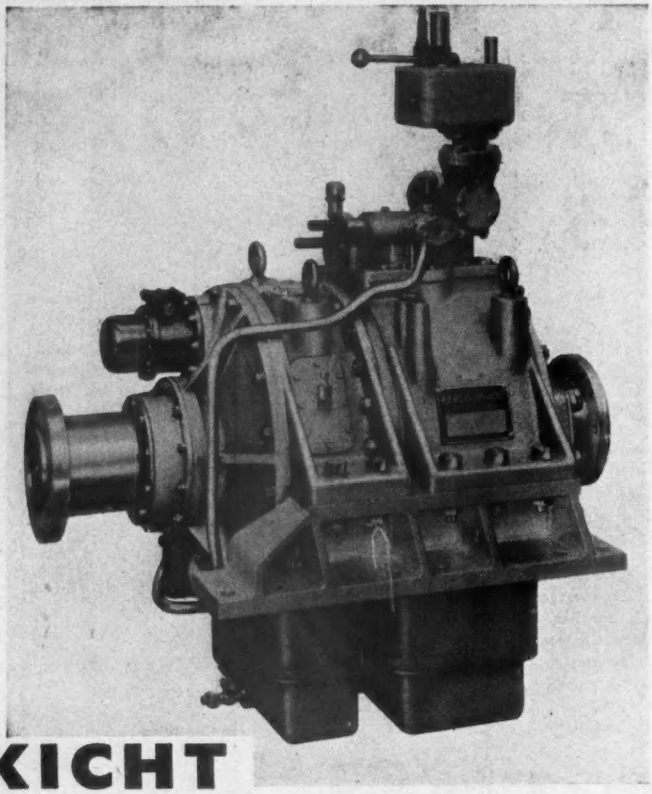

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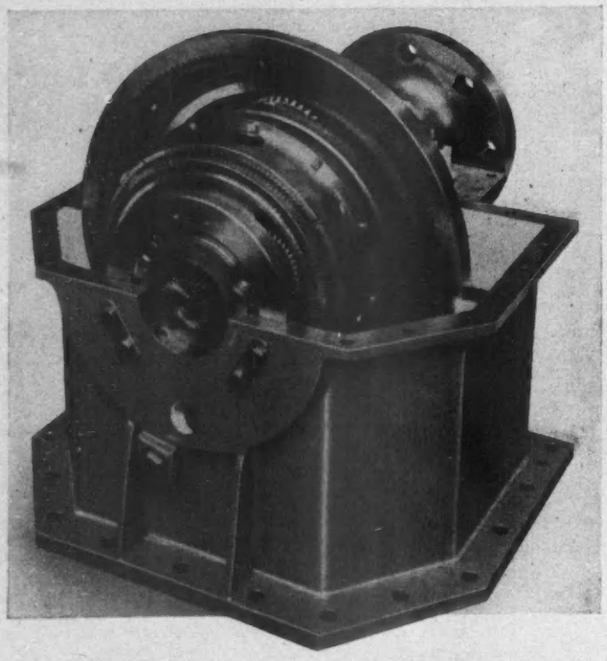

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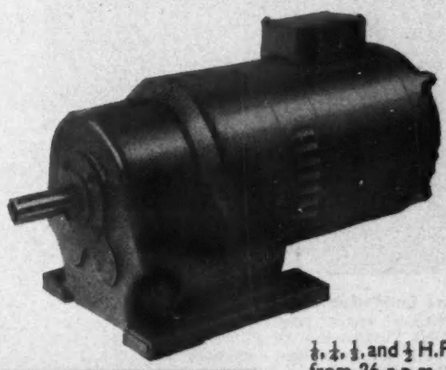

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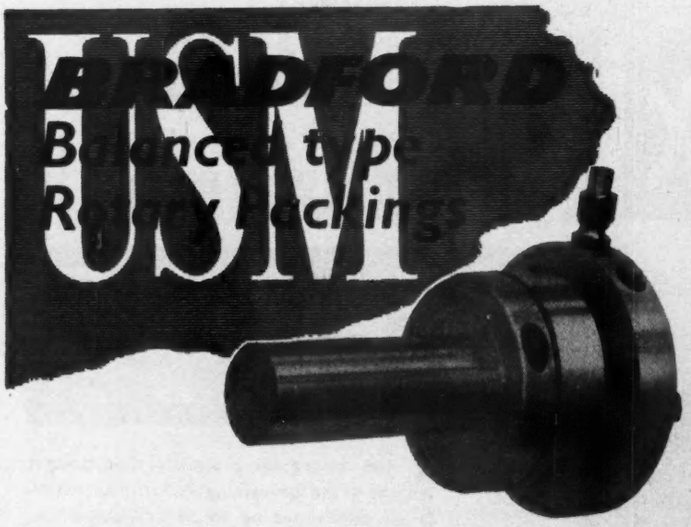

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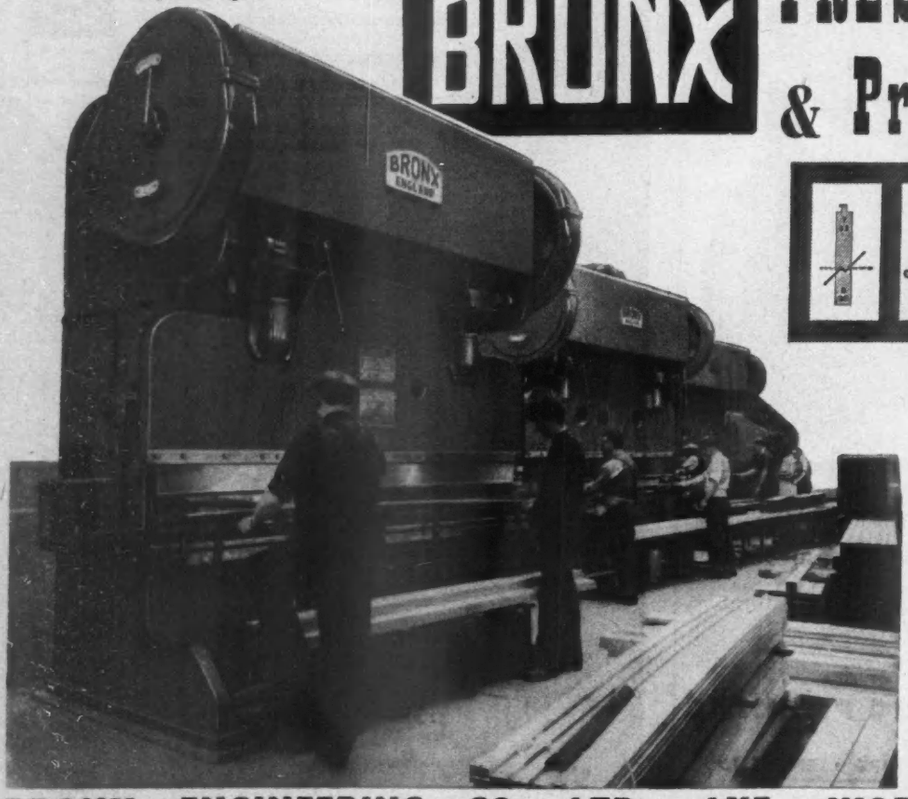

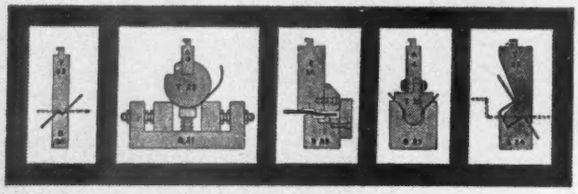

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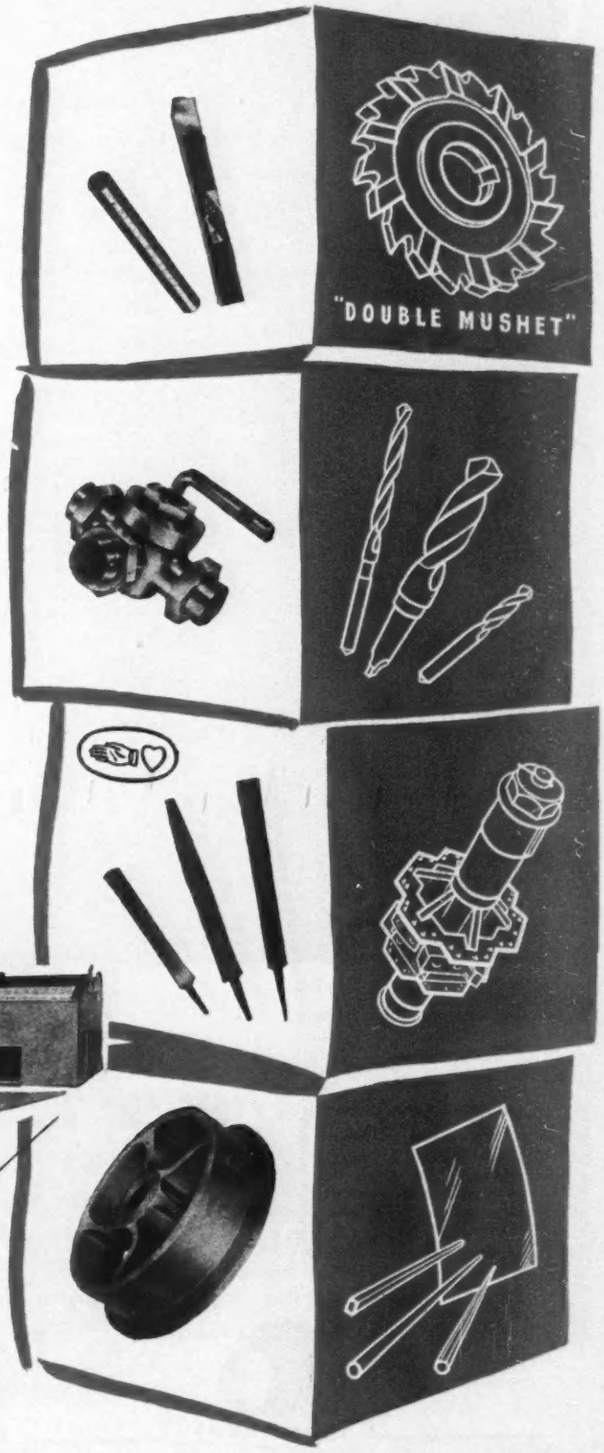

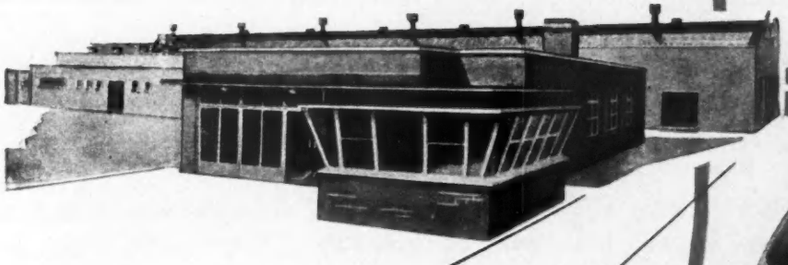

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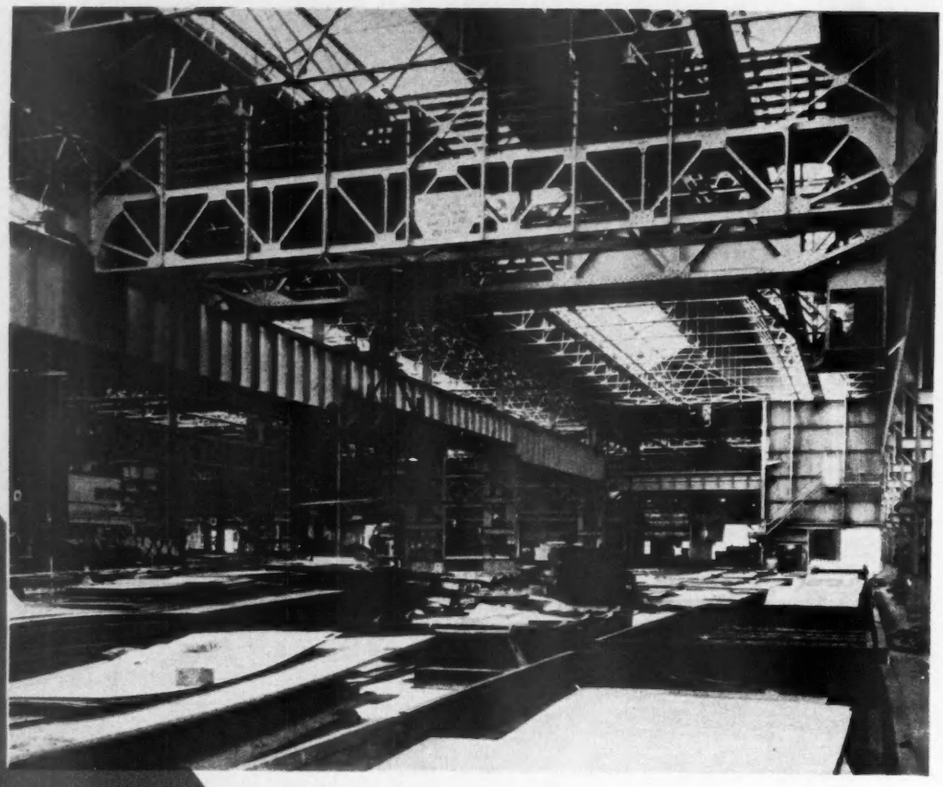

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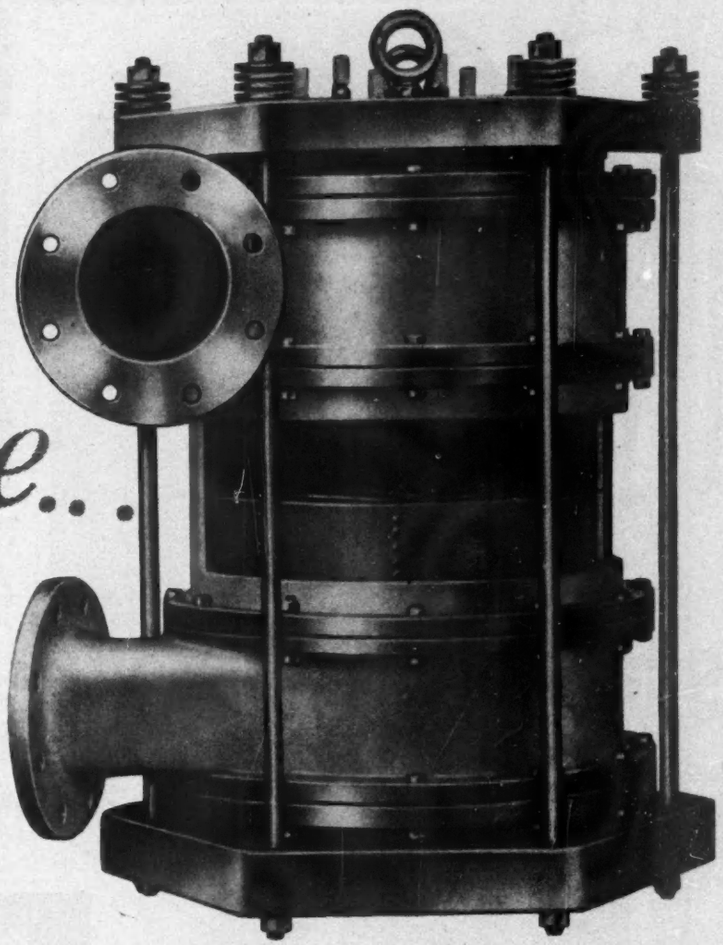

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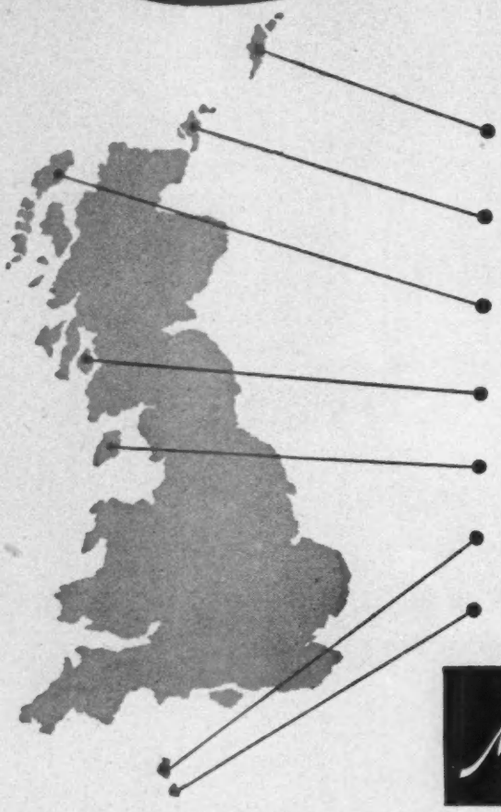

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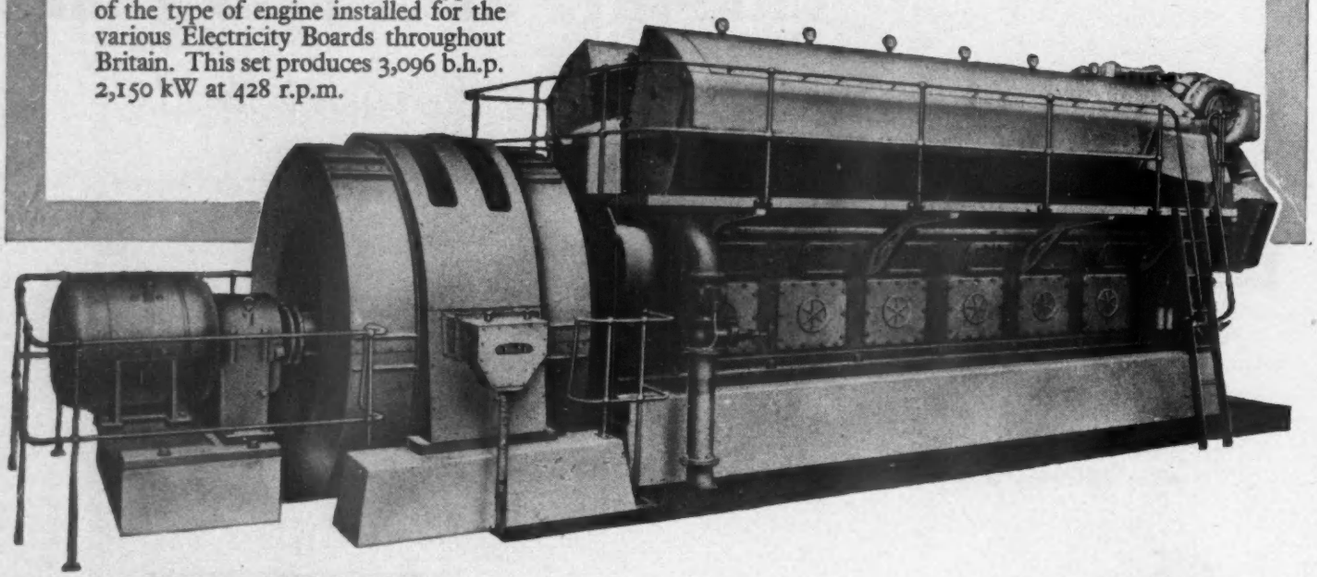

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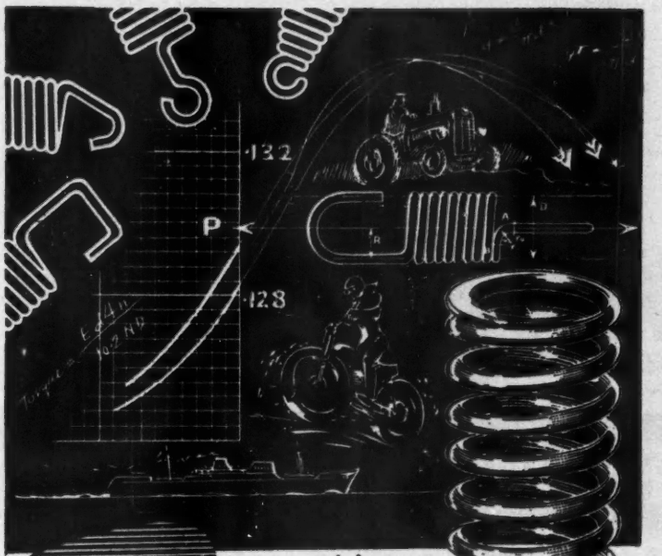

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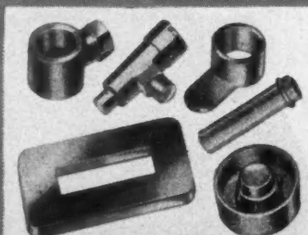

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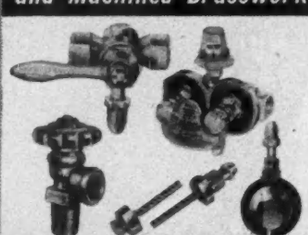

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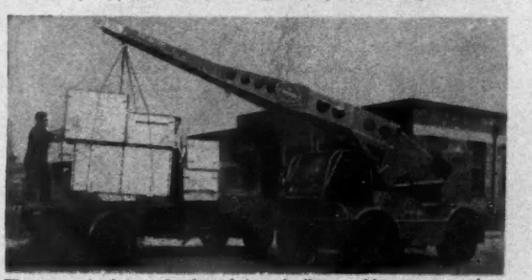

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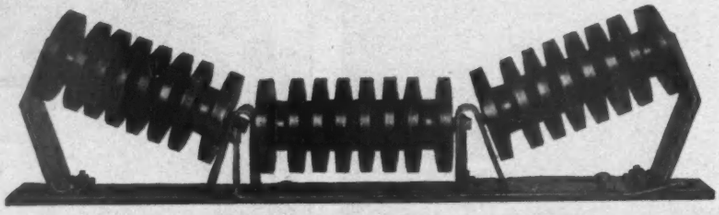

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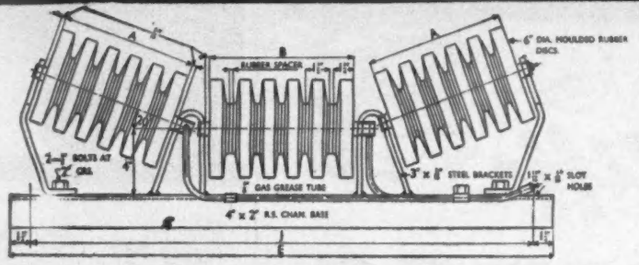

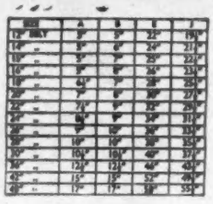

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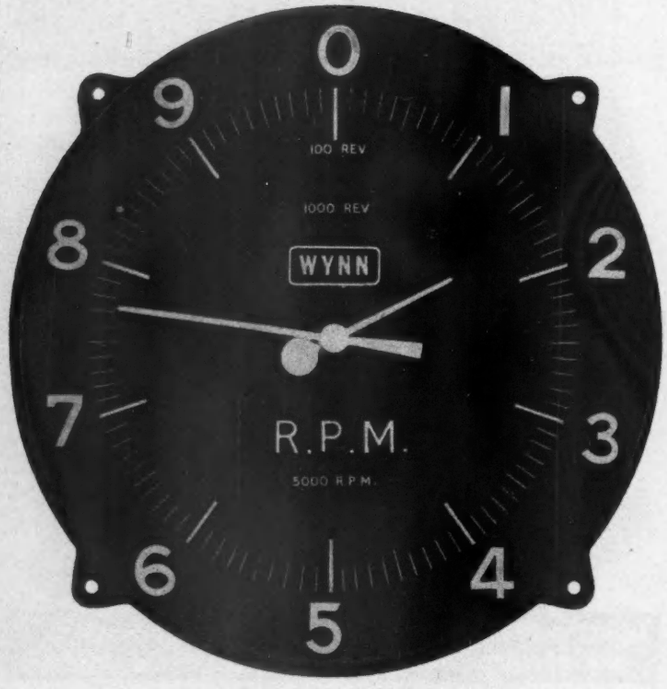

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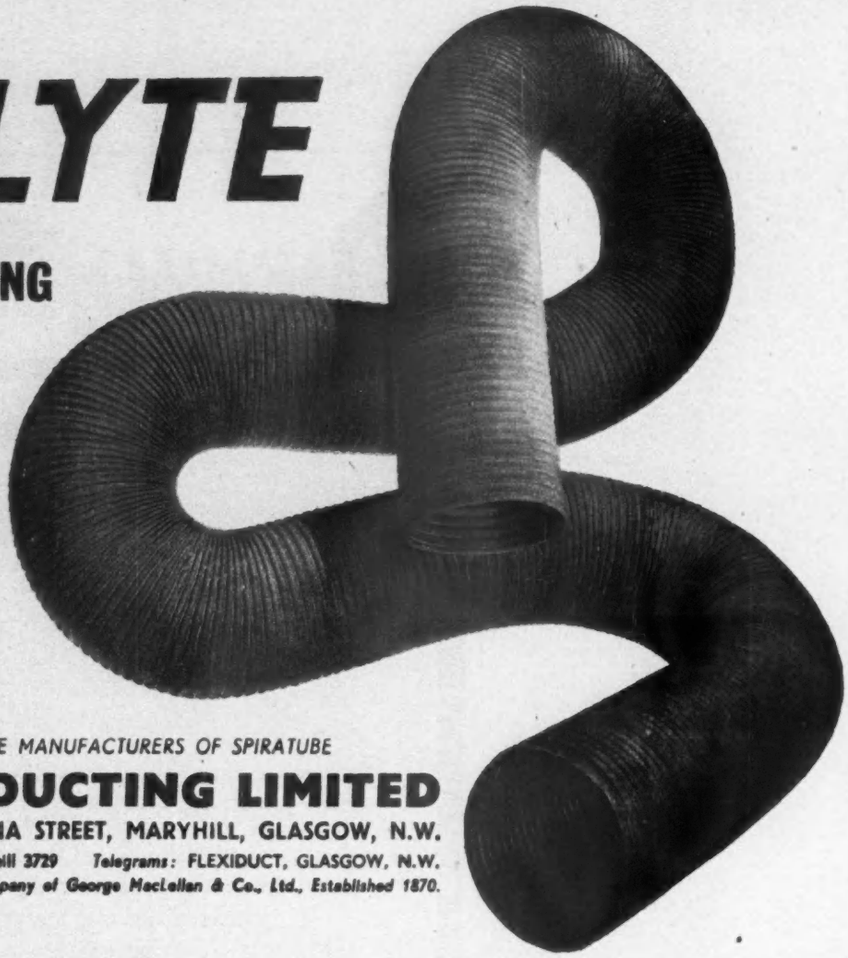

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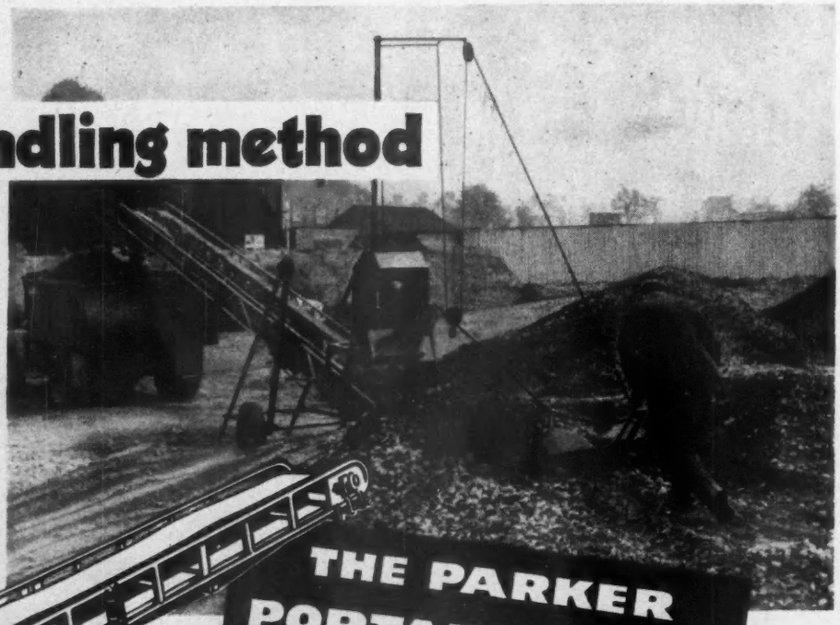

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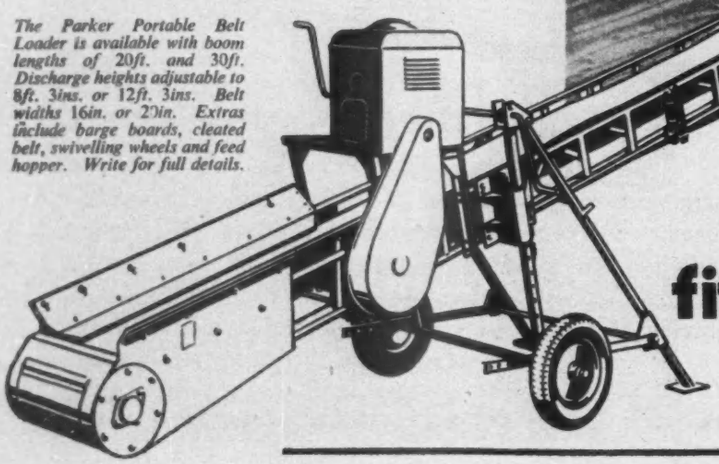

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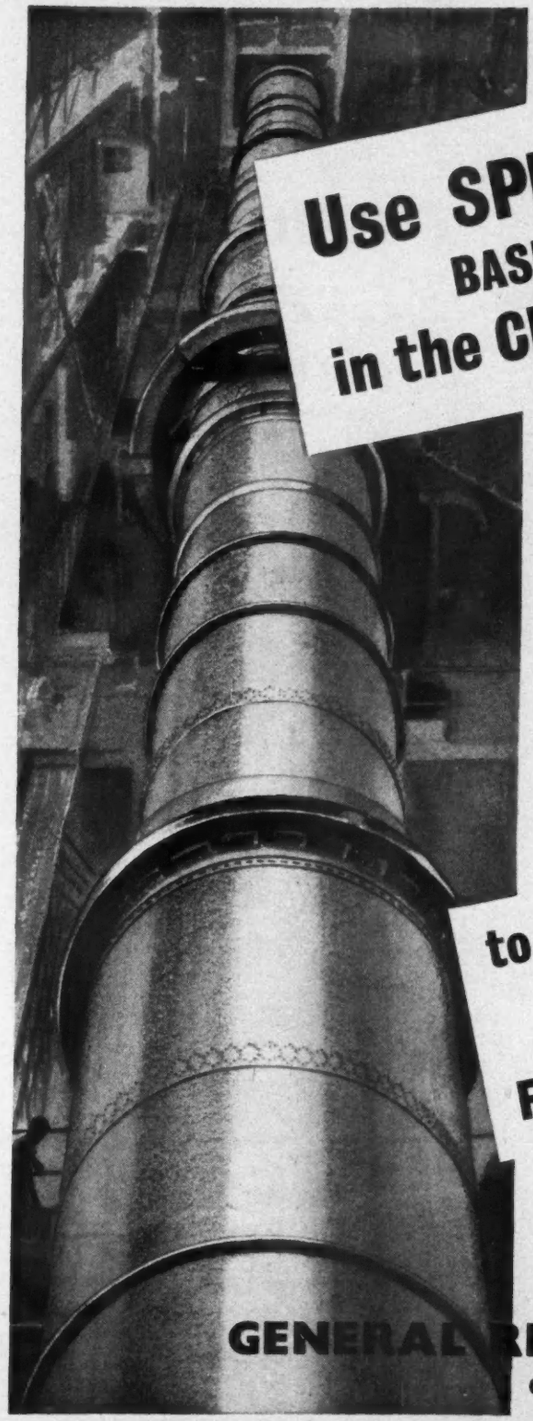

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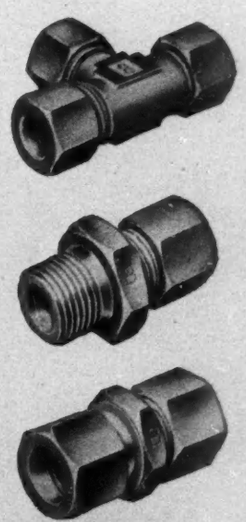

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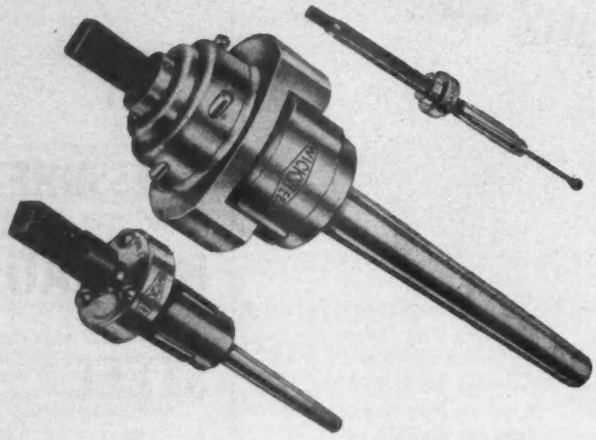

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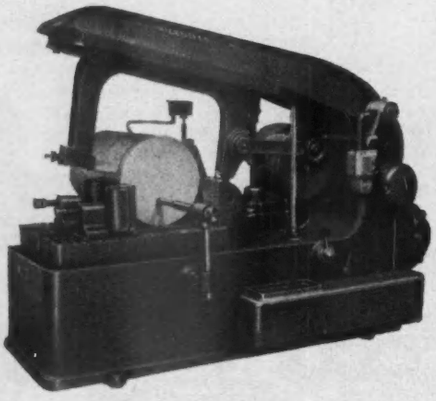

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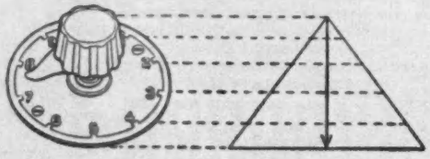

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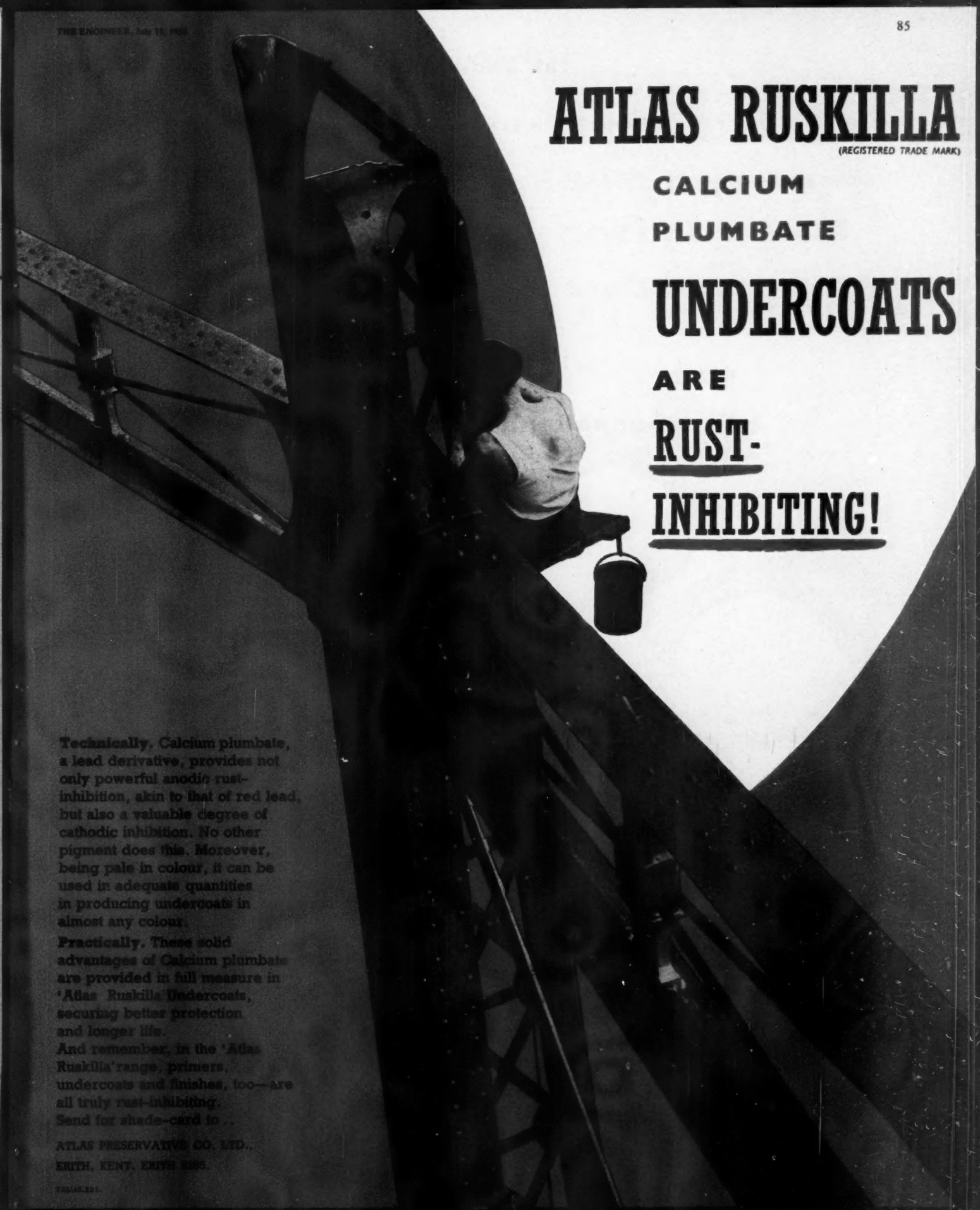

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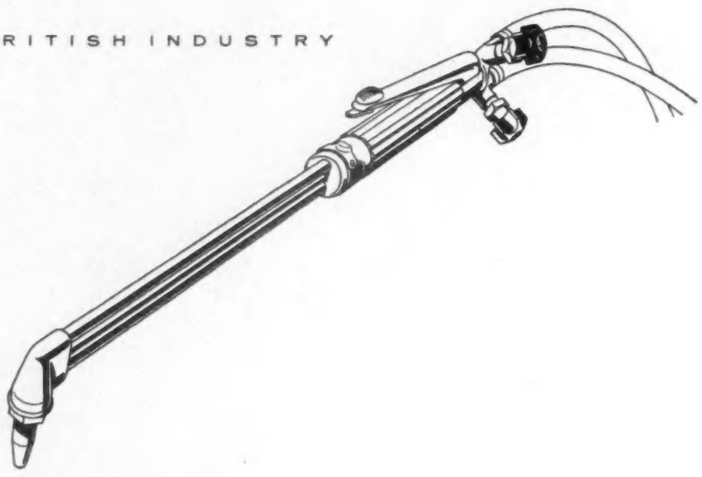

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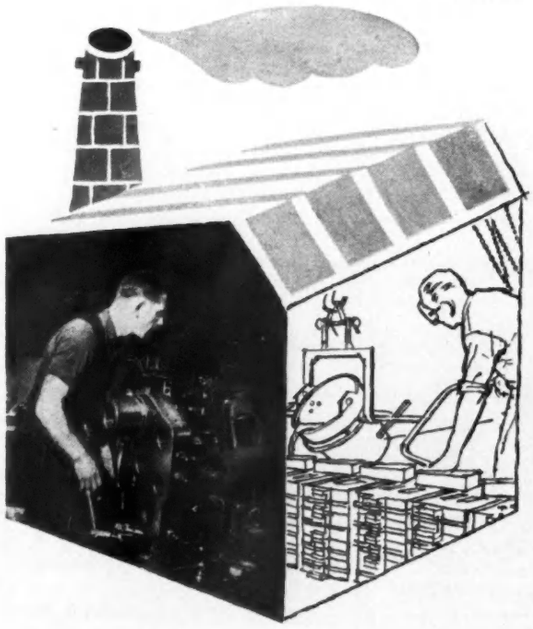

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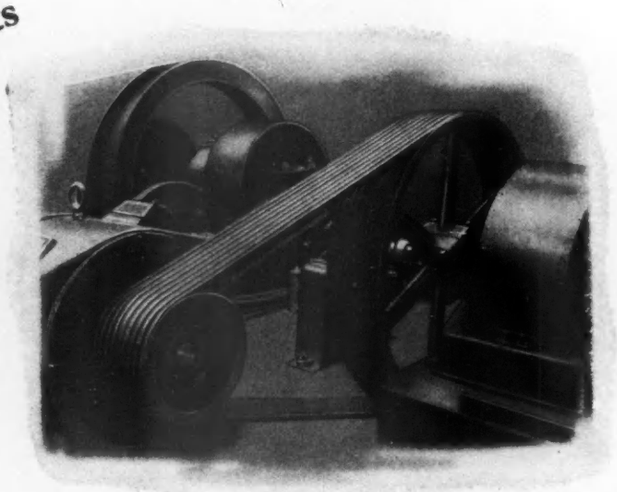

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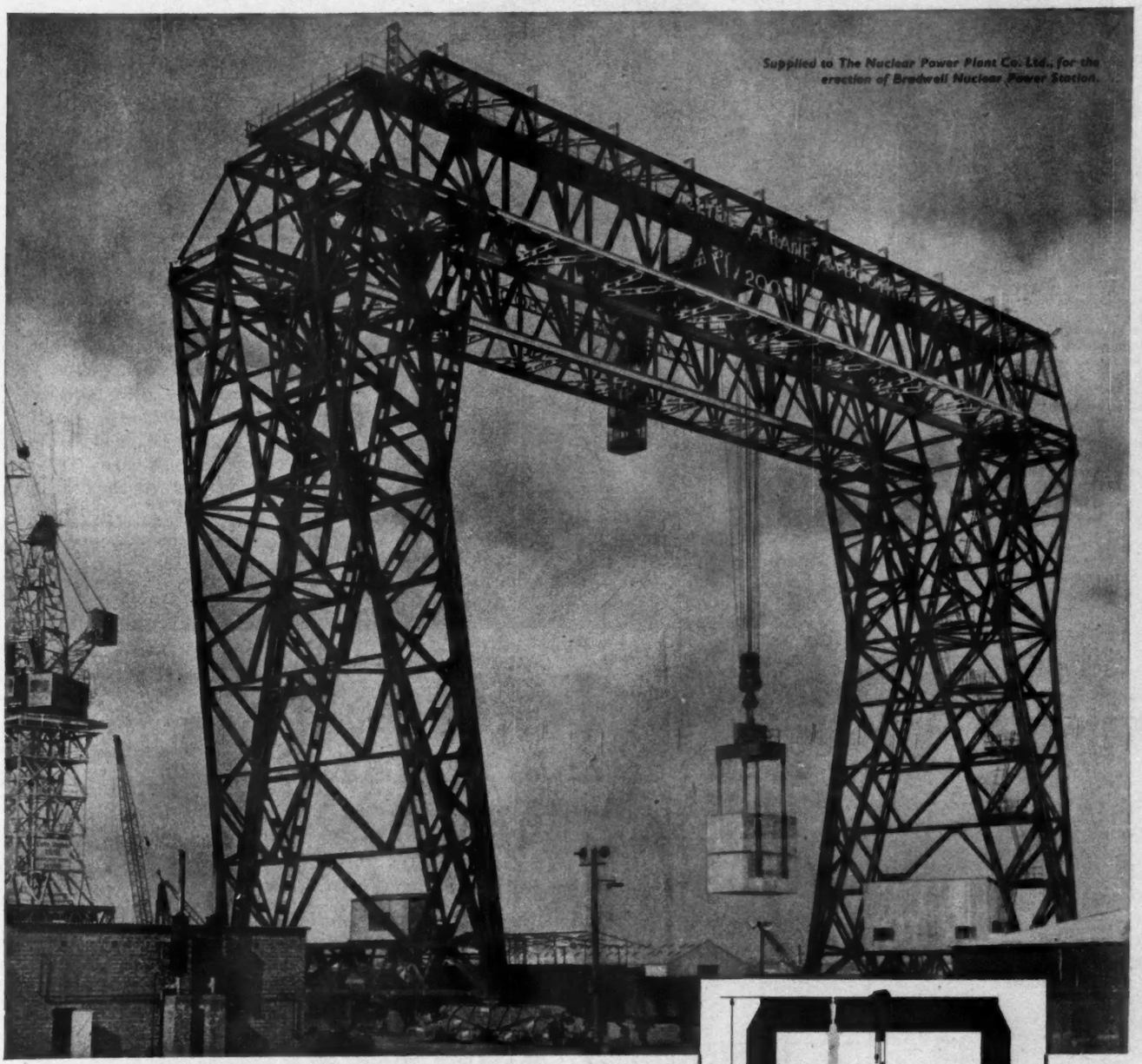
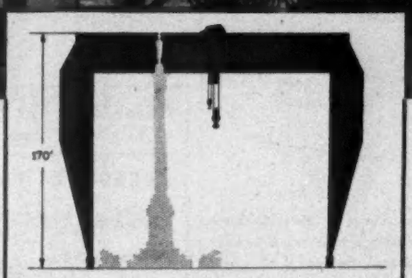


Shown lifting concrete test blocks representing the maximum working load of 200 tons, this Goliath was built by Clyde Crane & Booth Ltd., for the erection of Bradwell Nuclear Power Station. Taking into account the lifting capacity and overall dimensions, it is believed to be the largest of its type in operation in this country and probably the world.



The Booth Goliath showing Nelsons Column on the same scale. Clearance from rail level to underside of bridge is 140'. Distance between rail centres 178'.

CLYDE BOOTH

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incorporating

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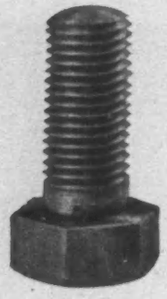
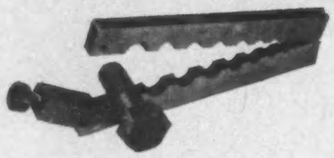
HOW MUCH FOR THIS?



. . . . not more than a shilling, maybe, but a single damaged bolt or other screw threaded part can cost pounds if a replacement is not readily available when it is wanted and essential machinery is standing idle. But there is no need to take chances because there is a certain safeguard and it costs only 27/6d.—the Edwards' Patent Bolt Saver and Thread Restorer!

Unquestionably, the Bolt Saver is the most efficient tool for restoring damaged threads and it is the easiest to use, too: Simply insert damaged part, close tool by means of clamp, withdraw part by unscrewing and—presto!—the damaged thread is as good as new, re-formed (*not* cut) and with full grip restored! Also invaluable as a thread gripper for holding threaded parts in the vice.



No inserts or loose parts and the one tool takes all sizes from ¼-in. to ½-in. dia. (BSP ¼-in. to ½-in.). There are models for the following threads: BSW, BSF, ANF/SAE, UNF, Metric, Motor-cycle and BSP, all at **27/6**

Guarantee

We invite you to make this test: Knock-up good threads with a hammer and recondition with the Bolt Saver—your money back if the corresponding nut cannot easily be screwed on!

Do not take chances—equip with Bolt Savers NOW, before the next breakdown! Immediate delivery through your usual supplier or direct from

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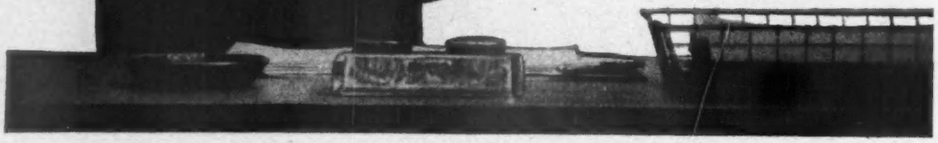

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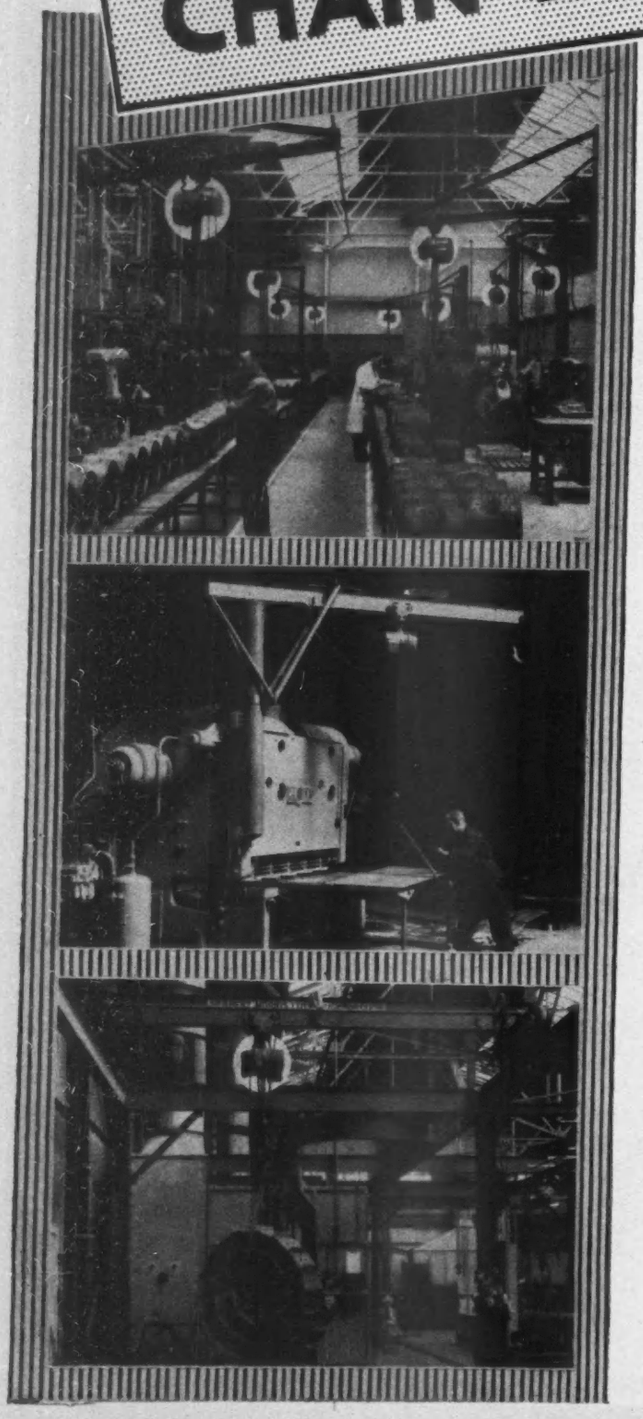
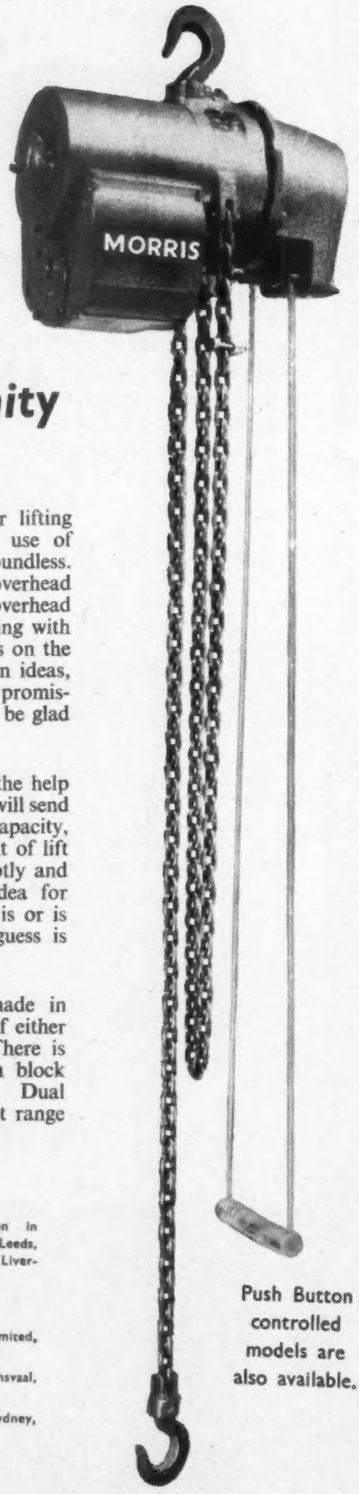
THE MORRIS *Electric* CHAIN HOIST

FOR AS LITTLE AS £70 YOU CAN ACQUIRE THIS DEPENDABLE HELPER IN YOUR BUSINESS





Push Button controlled models are also available.

Your opportunity to try one

The possibilities of improving your lifting facilities at moderate cost by the use of Morris electric chain hoists are boundless. Hang one of these hoists on a hand overhead crane, jib-crane, cat head, or overhead runway, and immediately, faster lifting with less effort is yours. The illustrations on the left may serve to stimulate your own ideas, and if you would like to try out some promising application right now, we would be glad to send you a hoist *on approval*.

Select a suitable type of hoist with the help of our folder Section 80/3 (which we will send you on request), let us know the capacity, electric current supply and the height of lift required, and you can decide promptly and on the spot whether your latest idea for speeding up a routine job of lifting is or is not a practical proposition. Our guess is that it will be !

Morris electric chain hoists are made in ¼-, ½- and 1-ton sizes, in the form of either pendant or push button control. There is also available a 2-ton electric chain block which is described in Section 74/3. Dual speed units in the electric chain hoist range can be supplied when required.

Resident engineers available for consultation in London, Glasgow, Manchester, Birmingham, Leeds, Sheffield, Newcastle, Cardiff, Bristol, Dundee, Liverpool, Nottingham and Bury St. Edmunds.

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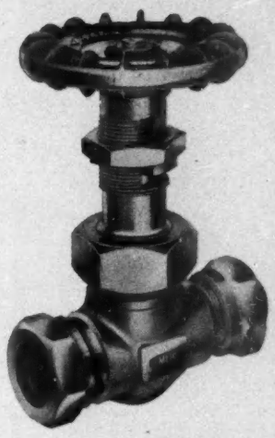
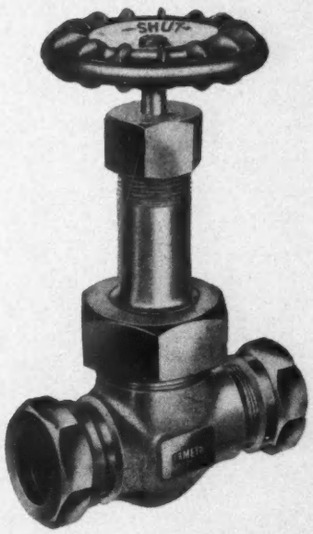
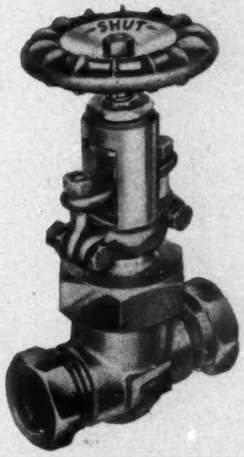


ERMETO Gate Valves are recommended for use with a wide variety of fluids at pressures up to 2,000 p.s.i. They are fitted with ERMETO High Pressure Joint end connections to suit N.B. pipe sizes from ¼" to 1½".





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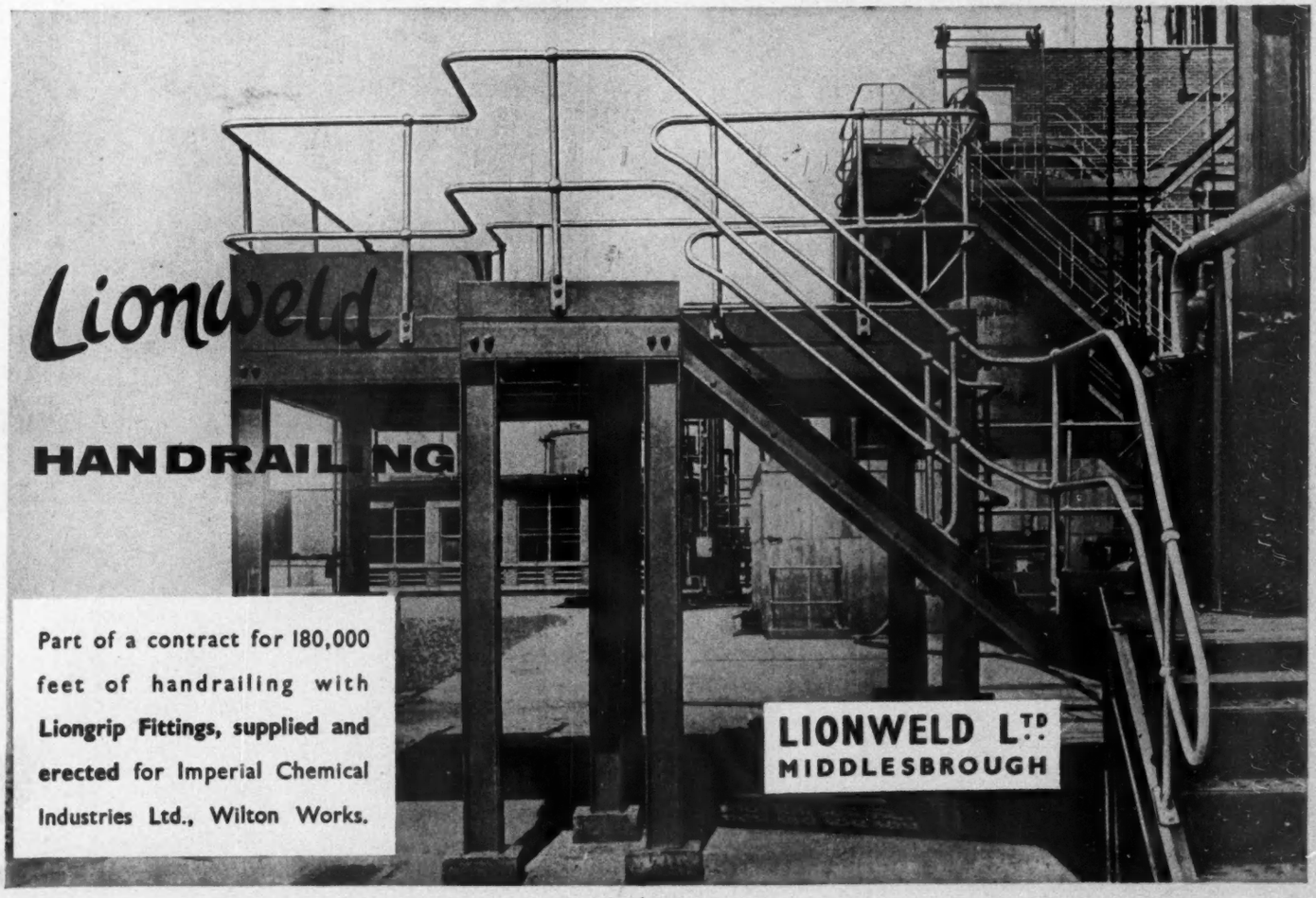
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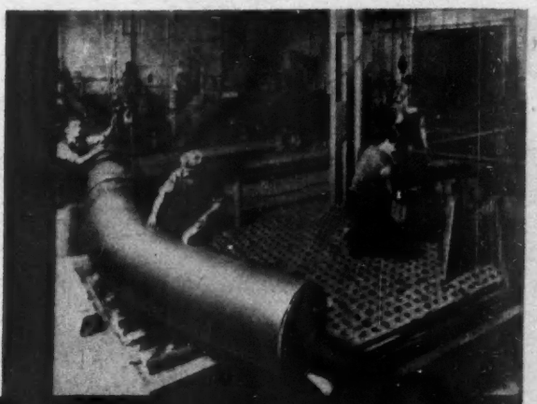
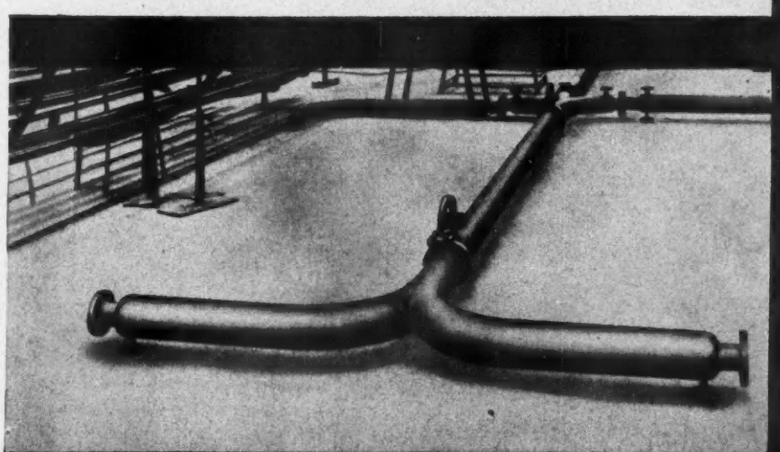
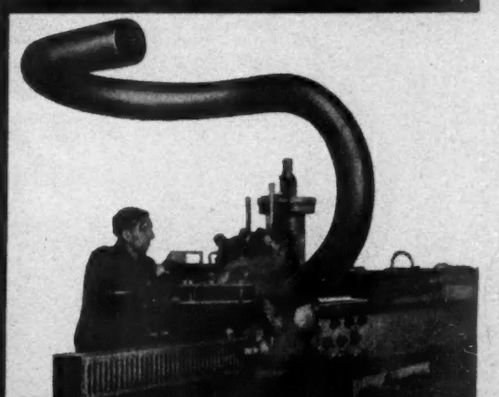


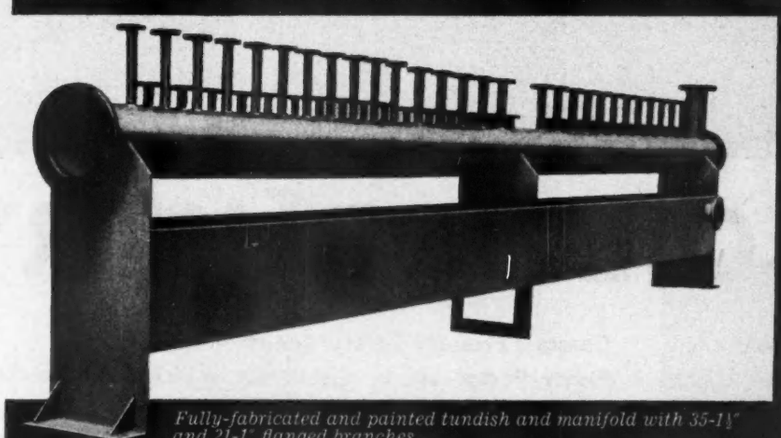
Fire bending process on a large bore steel pipe.



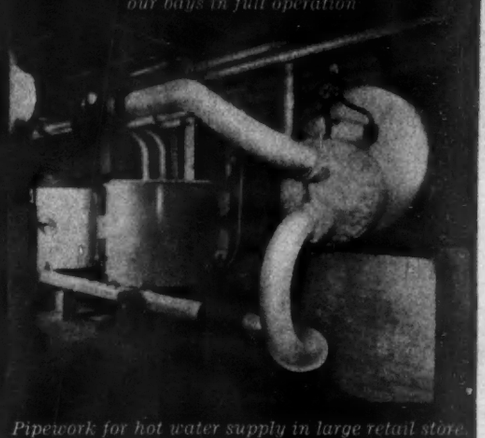
Steam-jacketed Bitumen pipeline for Kuwait Oilfields.



Bonn's Bending Machine installed in one of our bays in full operation



Fully-fabricated and painted tundish and manifold with 35-1½" and 21-1" flanged branches.



Pipework for hot water supply in large retail store

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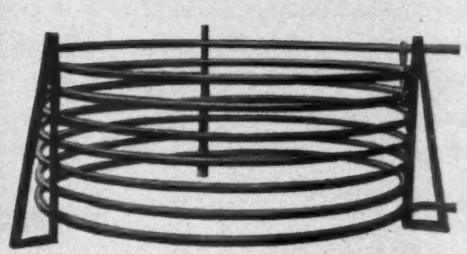

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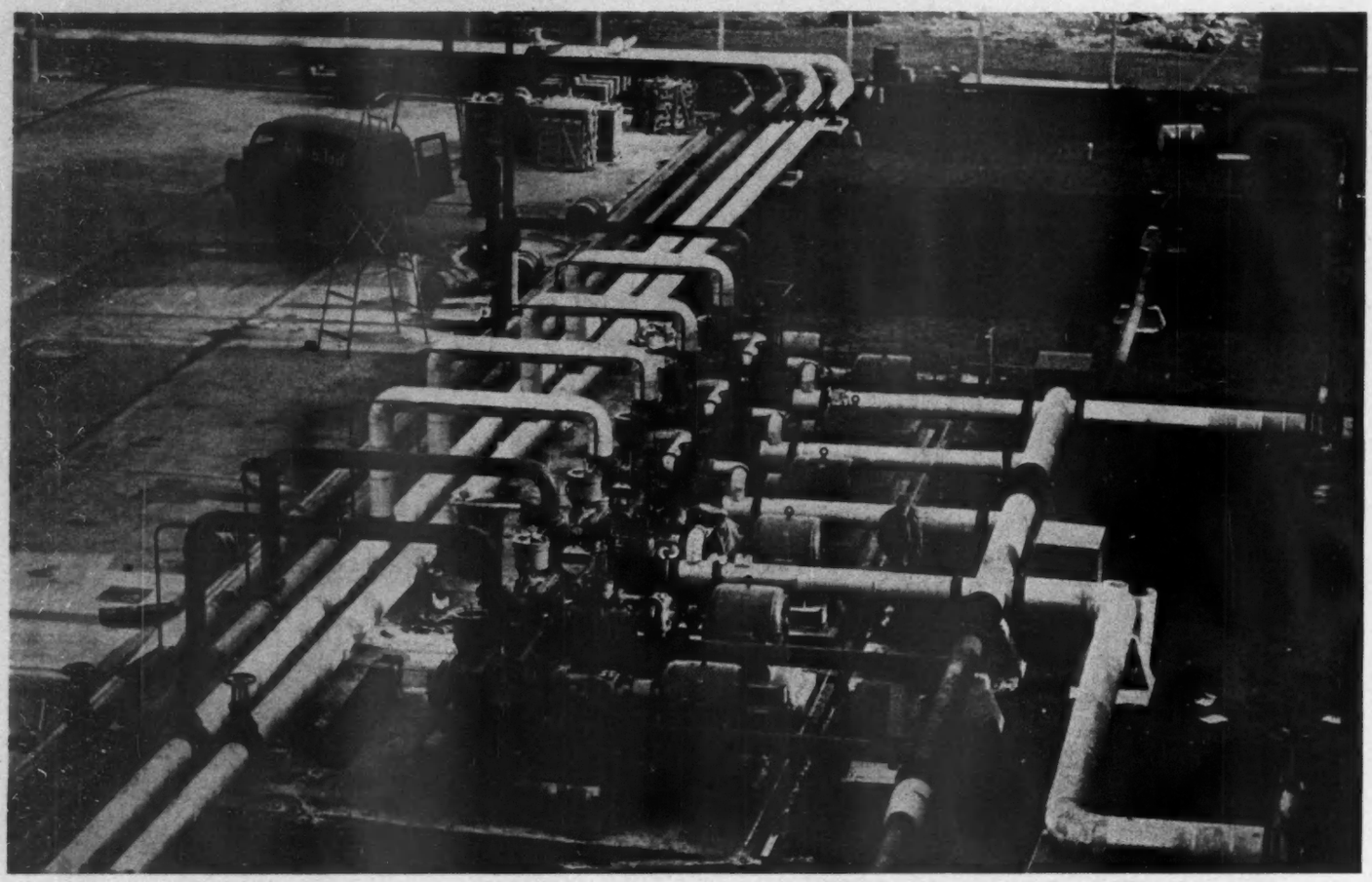

in the OIL INDUSTRY

Shown above are six 150 tons per hour automatically controlled Plenty Pumps supplying the tank car loading gantries at the Coryton Bulk Terminal of the Mobil Oil Company.

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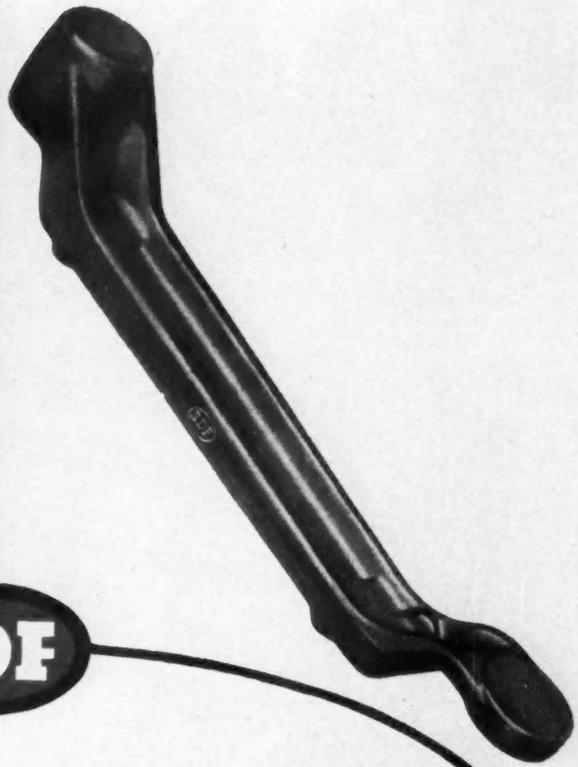

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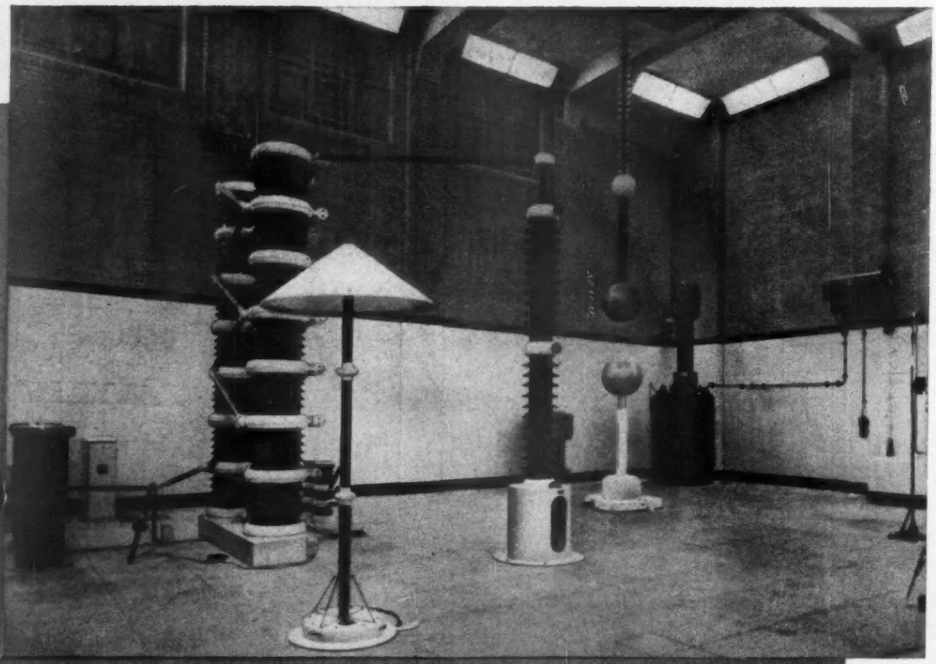

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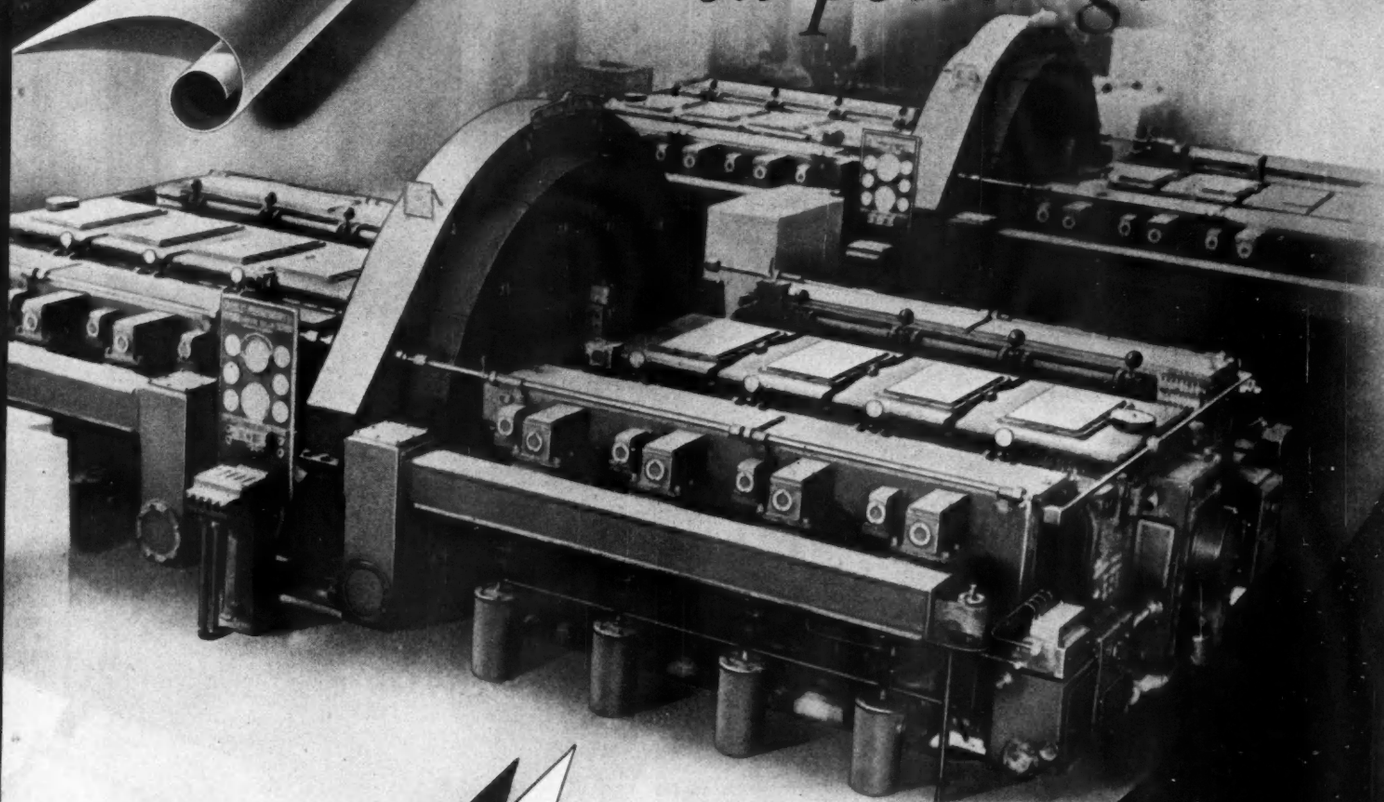

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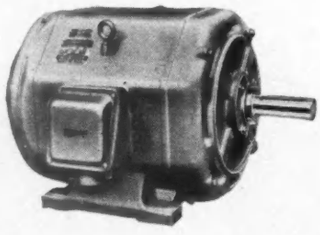

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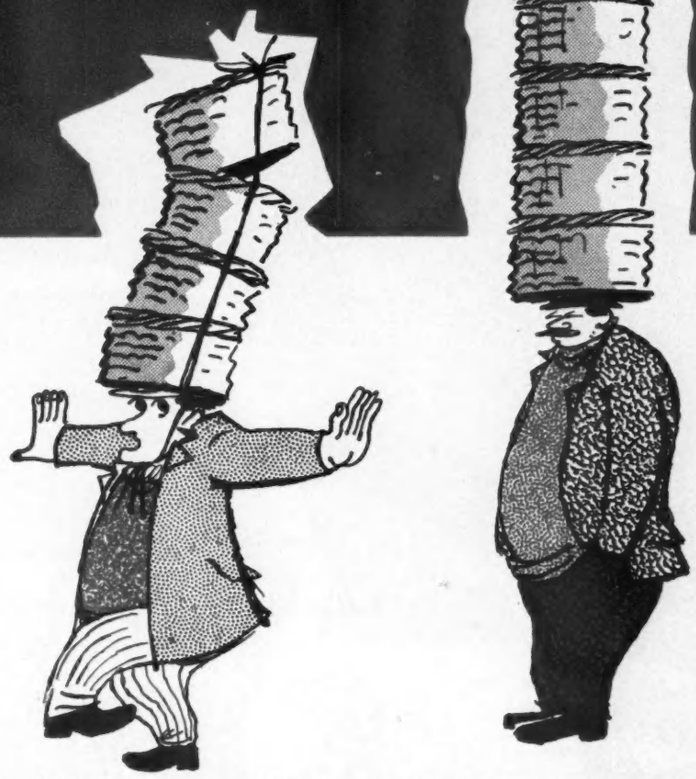

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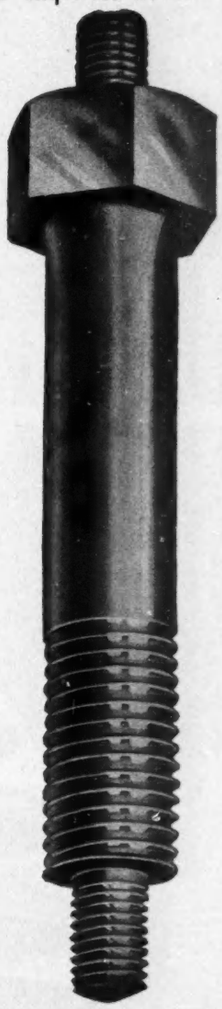

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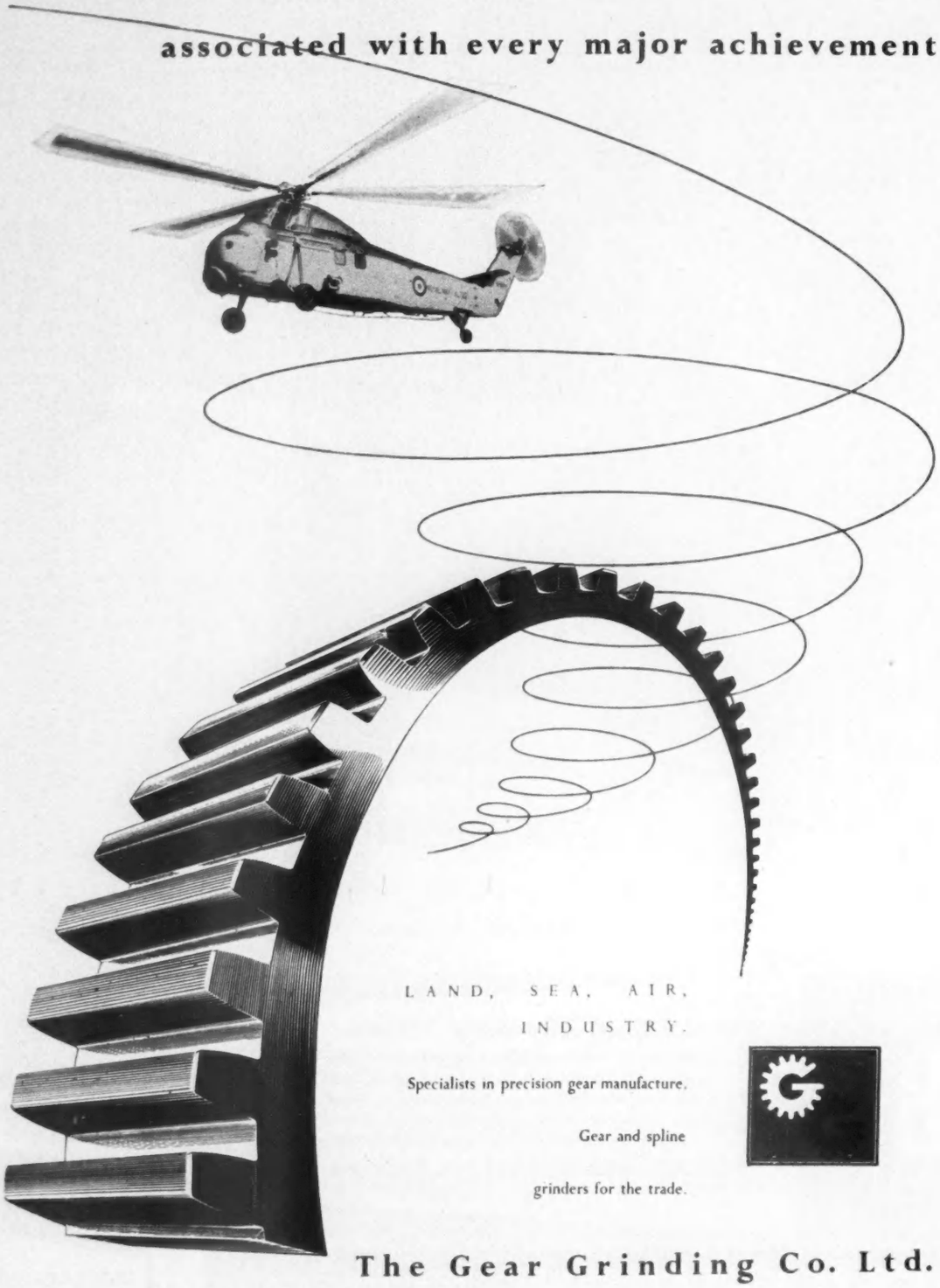

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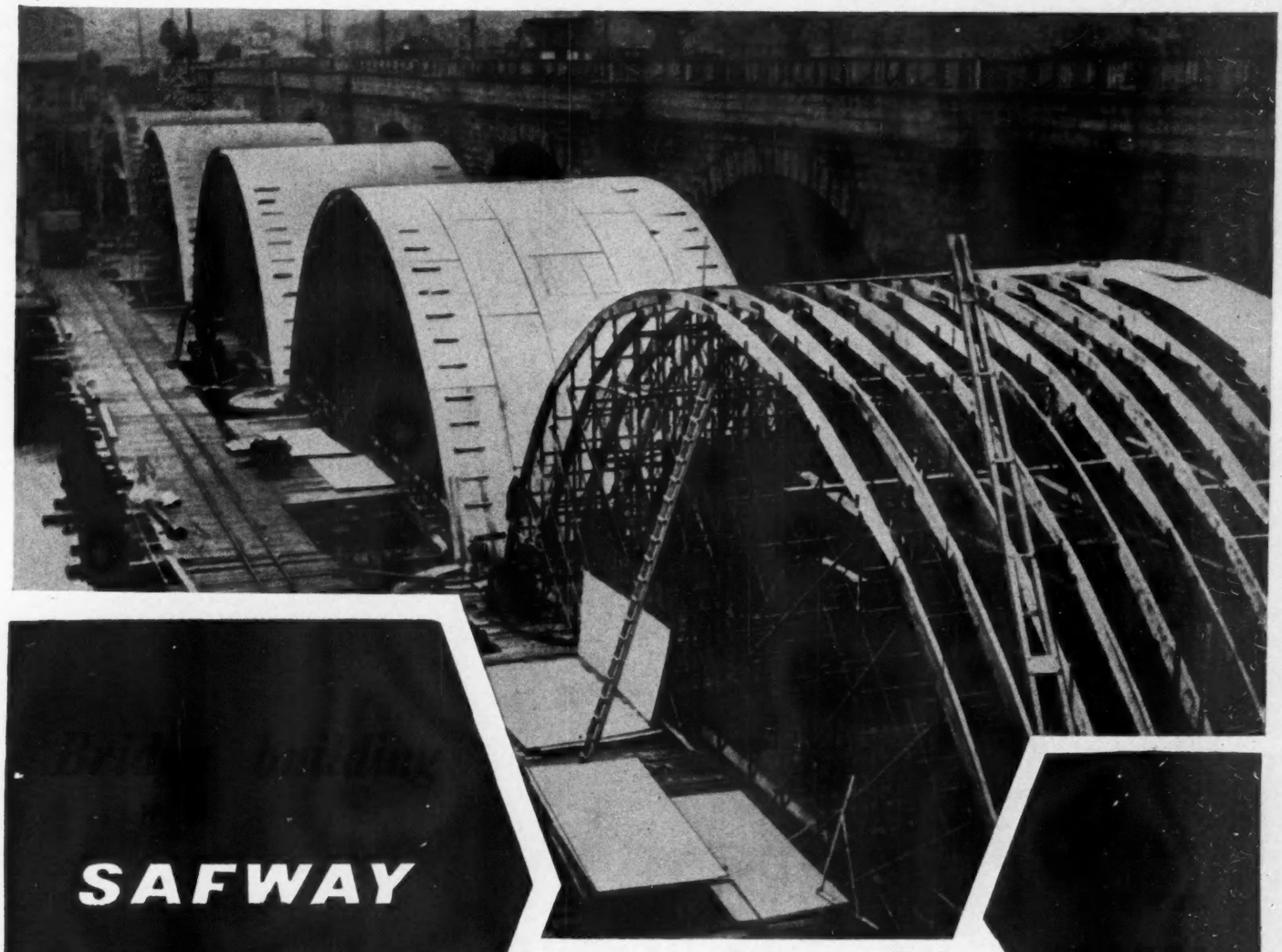

SAFWAY

Photo by courtesy of the City Engineer, Aberdeen — A. G. Booth, M.E., A.M.I.C.E.

1 The whole of the scaffolding supporting the shuttering for this bridge erected in 1,100 man hours.

2 Labour force of only five men on scaffolding (3 of which were unskilled).

3 Only Safway equipment used throughout.

4 Size of each arch 75ft. x 26ft. 6ins. x 28ft. 6in. wide. Total load per arch 215 tons.

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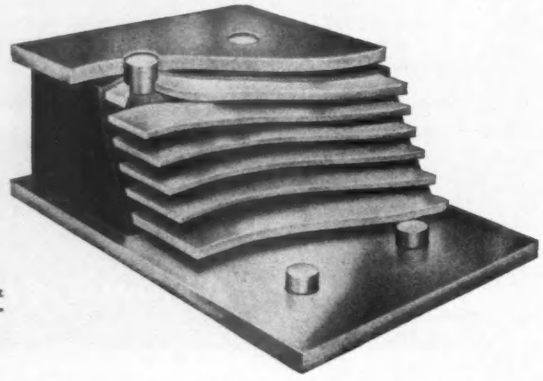

One of the mountings cut away to show the rubber-metal construction.

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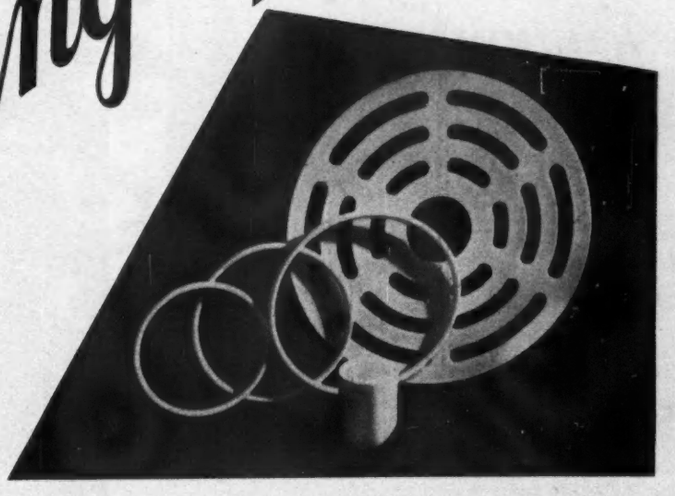

The material processed at Klingerit Works, Sidcup, is "Fluon" which is the trade name for the P.T.F.E. manufactured in Great Britain by Imperial Chemical Industries Ltd.
Included in the list of articles sold by Richard Klinger Ltd. under their trade mark "KLINGERFLON", are O-rings and Chevron type packing rings, as illustrated.

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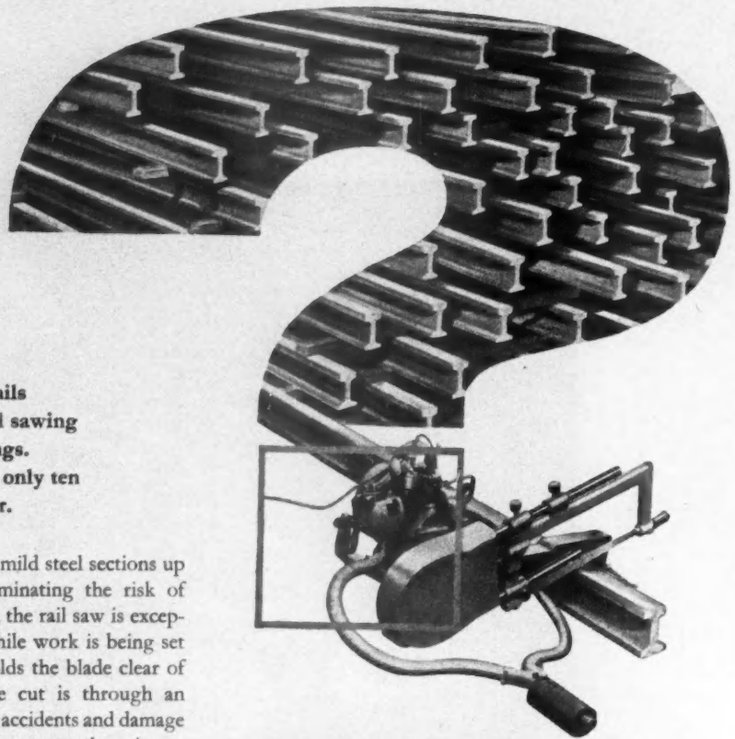

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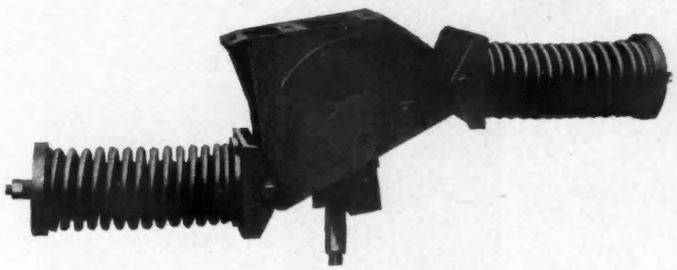

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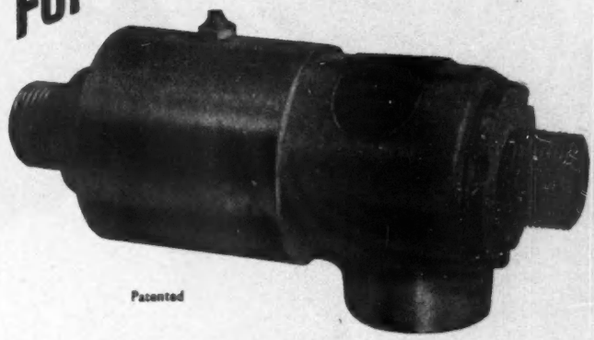

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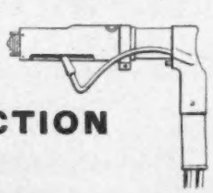

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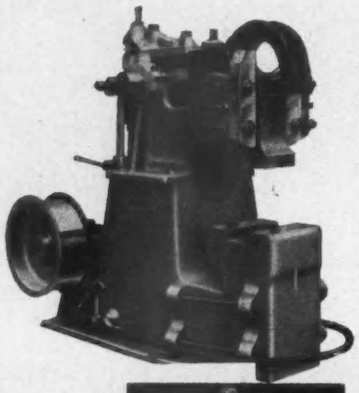

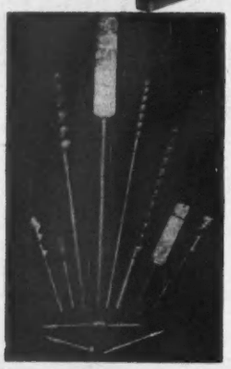

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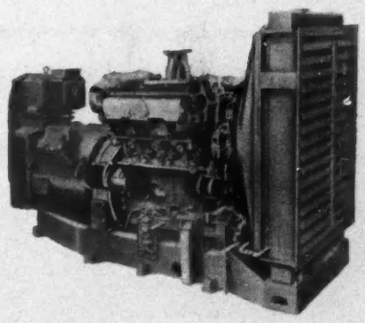

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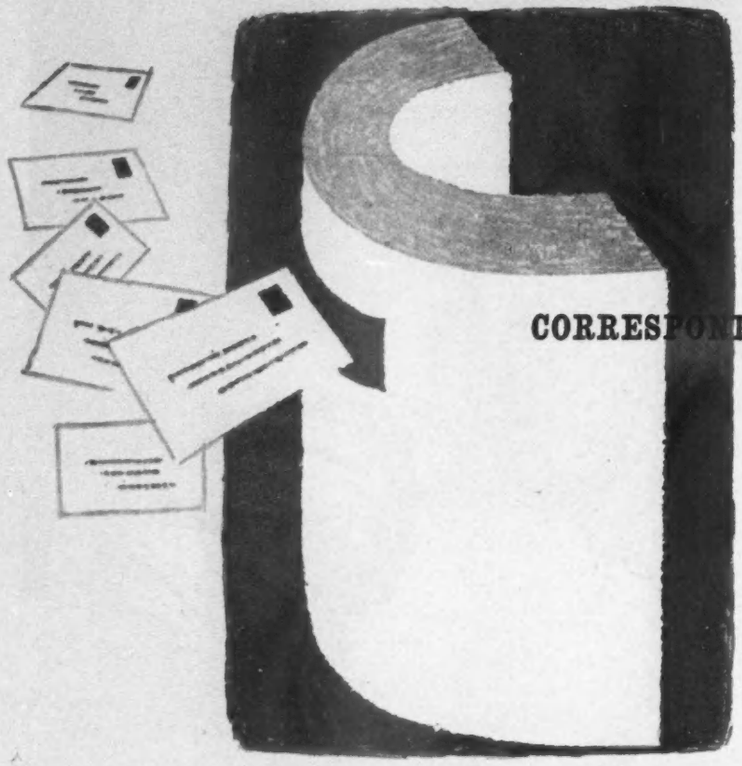

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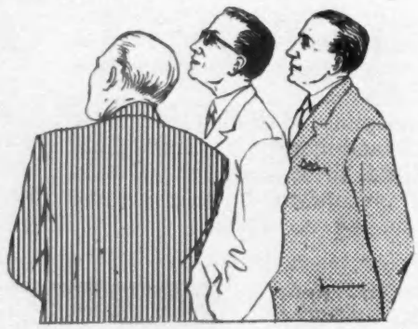

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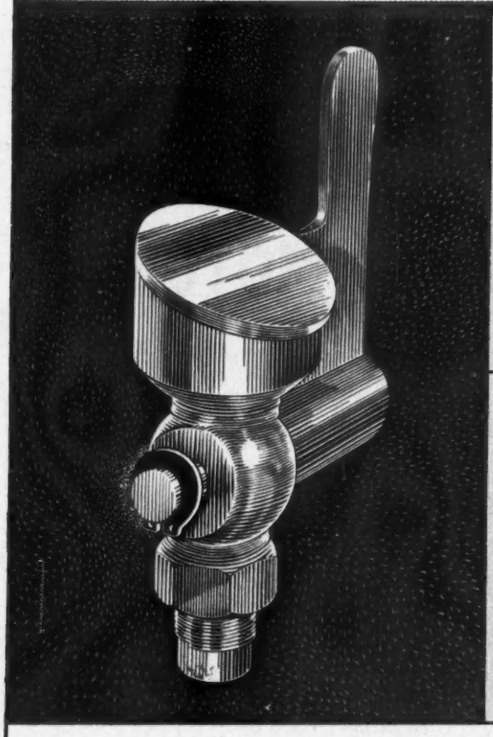

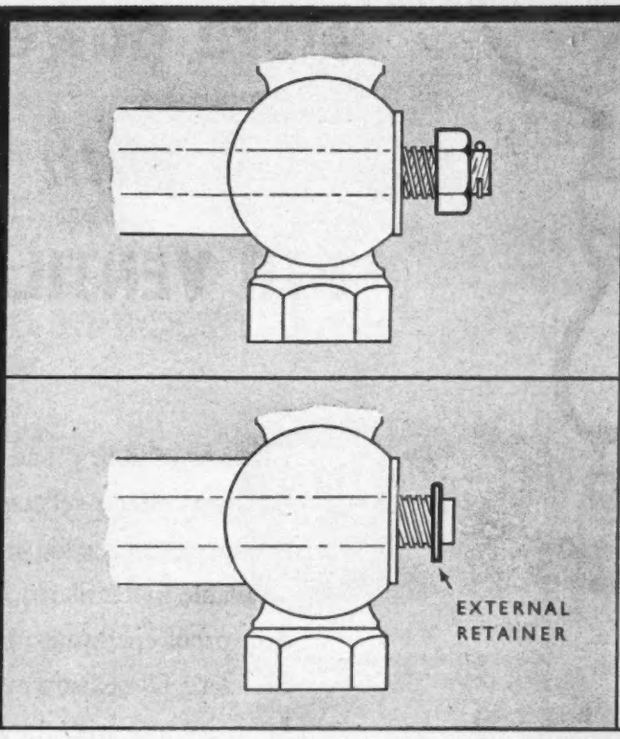

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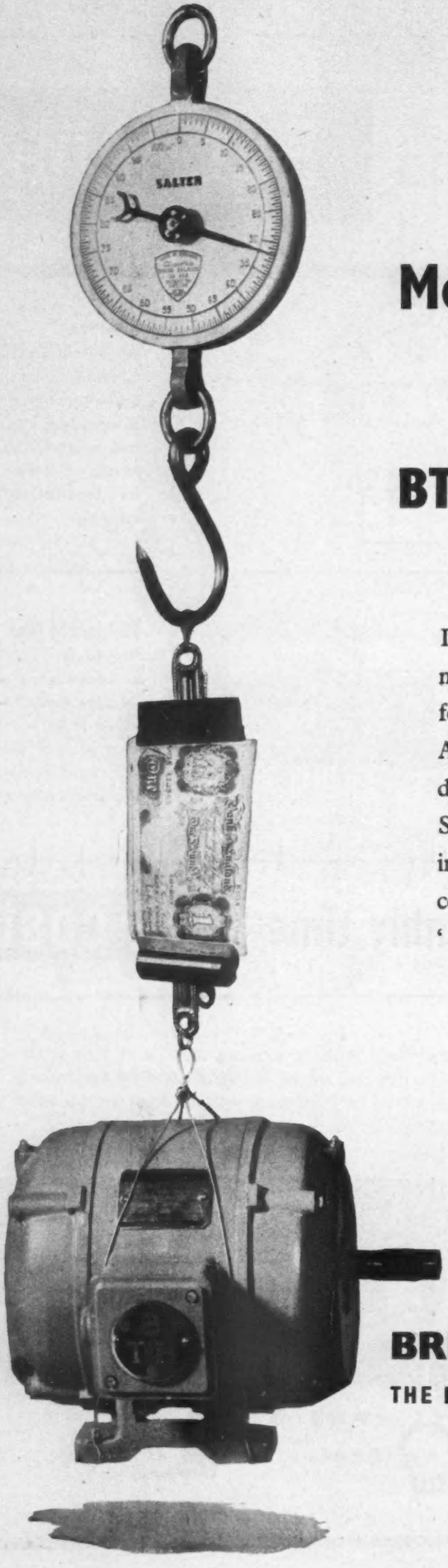

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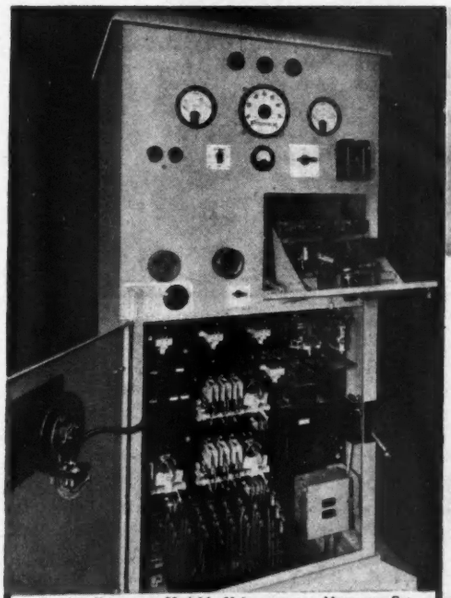

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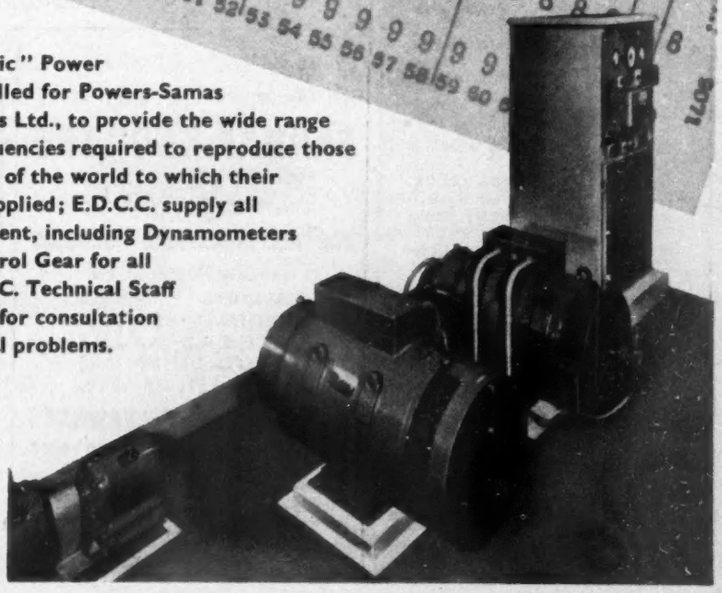

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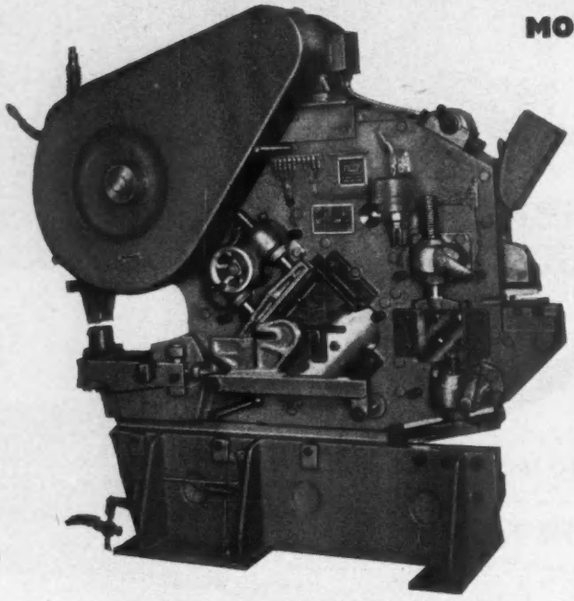

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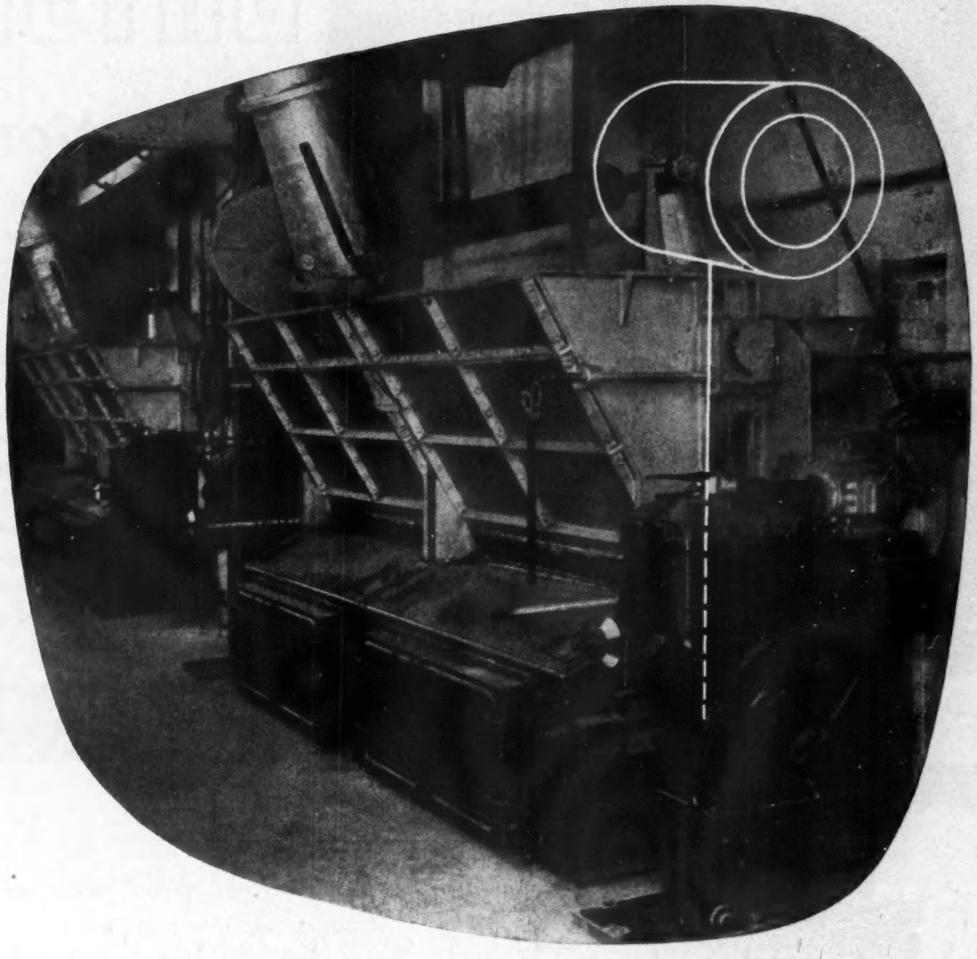

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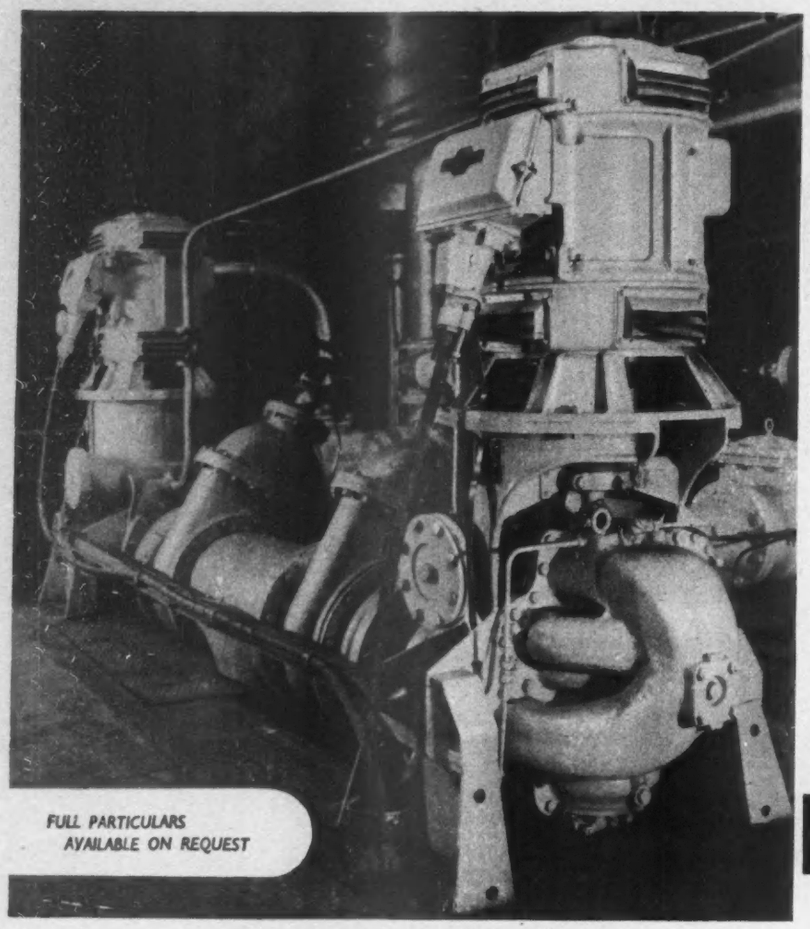

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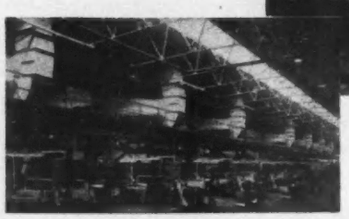
Specify "Tornado" FAN ENGINEERING EQUIPMENT

MORE AND MORE PLANT for fume and dust extraction, cooling, drying and other applications is being installed incorporating all types of 'Tornado' fan engineering equipment. The success with which such plants are operating throughout a wide range of industry results from the combination of our own extensive experience and the close collaboration of leading contracting and consulting engineers.



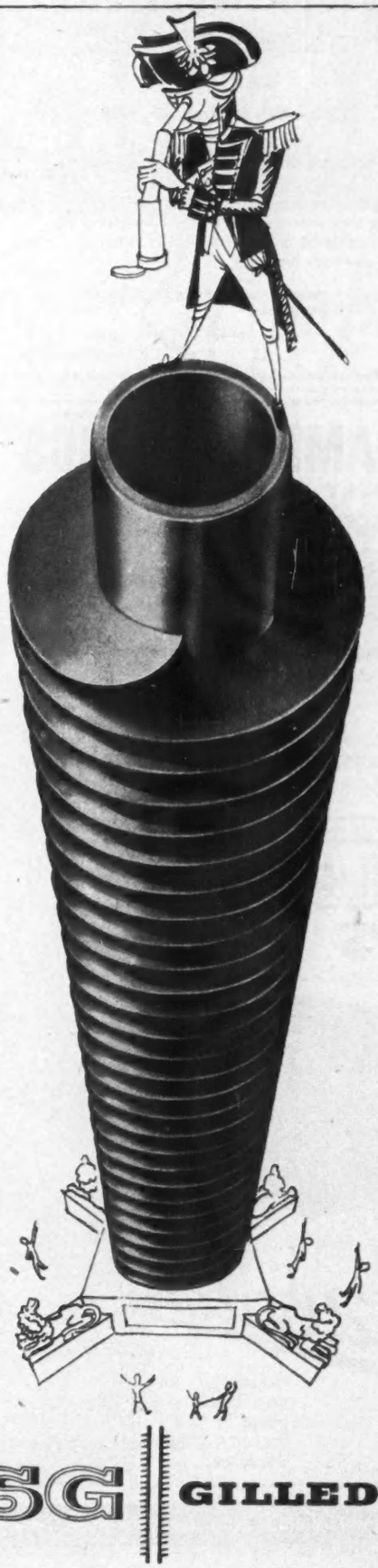
FUME REMOVAL
Plant for extracting fumes from hot dip tinning processes.
Photos by courtesy of The Steel Company of Wales Ltd.

When faced with any industrial problem of movement or treatment of air or gases, specify 'Tornado' equipment by

KEITH BLACKMAN LTD
MILL MEAD ROAD · LONDON · N17

Branch Offices: Birmingham · Bristol · Glasgow · Leeds Leicester · Manchester · Newcastle-upon-Tyne.

872



What's in a tube ?

Rather more than meets the casual glance when it's S.G. Gilled Tubing. Points that the naked eye would miss, that none the less show up in such important factors as high gill efficiency, low air pressure loss, performance under adverse conditions.

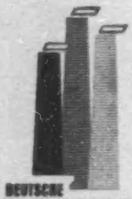
This technical superiority, coupled with low prices made possible by high output, makes the use of S.G. Gilled Tubing the economical answer to an increasing number of heat exchange applications.

As the leading specialists in the gilled tubing field, with design, testing and manufacturing resources equal to the best in the country, the service we offer is unrivalled. Tubes supplied with gills of several types, in various combinations of ductile metals, to standard dimensions or to special needs. We also build all types of heat transfer equipment ; to your design or designed by us for you. Our Technical Dept. is entirely at your service.

SG GILLED TUBING

SPIRO-GILLS LTD., HEAD OFFICE AND WORKS: LONDON ROAD, PULBOROUGH, SUSSEX. *Tel: PUL 2401-5*

T.A. 9170



DEUTSCHE INDUSTRIE-AUSSTELLUNG BERLIN 1958 13. SEP. 28. SEP.

GERMAN INDUSTRIES EXHIBITION

BERLIN

13th—28th September, 1958

The Latest developments will be on view :

Aluminium—Chemicals—Copper—Electro Technical Industry—Engineering—Iron & Steel Industry—Machinery—Non-ferrous Metals—Sewing & Textille Machinery—Tools—Wire Industry —Wood Processing

53,450 square meters, 15 Halls, 9 Foreign Pavilions including Great Britain.

Passes & Information :
M. Neven du Mont.

123 Pall Mall, London S.W.1.
(Tel : WHI 8211)

STEEL FRAME BUILDINGS

OF EVERY DESCRIPTION

Factories, Sheds, Mill Buildings, Bungalows, Etc., Etc.,

SPECIALITIES: Pit Headgear, Pumping Stations, Power Stations

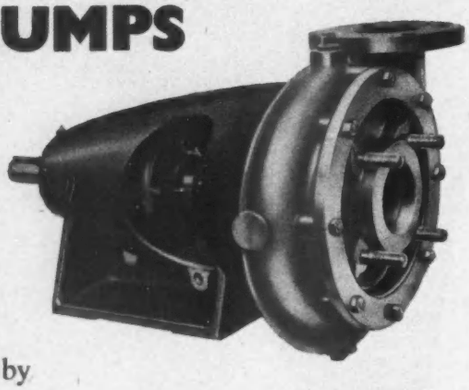
Bridgework and Riveted Work of all descriptions

BROWNLIE & MURRAY LTD.

POSSIL IRONWORKS, POSSIL PARK, GLASGOW

LONDON: 32 QUEEN VICTORIA ST., E.C.4

STAINLESS STEEL PUMPS



made by

Girdlestone

Centrifugal Pumps available with liquid end or complete pump in 18/8/3 stainless steel. Packed stuffing boxes or mechanical seals.

For details send for this folder now!

GIRDLESTONE PUMPS LTD.

23, Davies St., W.1. MAYfair 1354

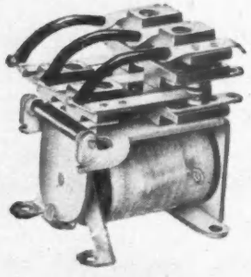
T.113

THORN

Vibration-proof relays

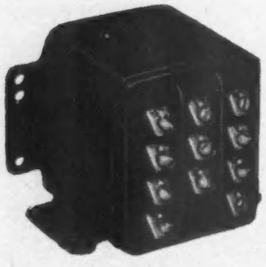
for aircraft and industrial use

These examples from the Thorn range of relays are of simple and robust construction and are designed to work under adverse conditions. The use of such features as high contact pressures and generous wiping action enables the T.10 series in particular to comply with the Service requirements of DES.1 and DEF.5000. Both sealed and open types are available with up to 4-pole changeover contacts. The standard relays operate on 28 volts D.C. and enquiries for other operating voltages are invited. Hermetic enclosure of the sealed types ensures complete freedom from the effects of humidity, altitude and tropical exposure. Also the case protects the relay from mechanical damage and operator interference.



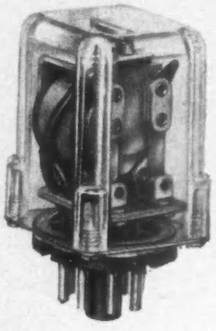
OPEN RELAY T.10.CU

Weight: 4.5 ozs.
Dimensions: $1\frac{7}{16}$" x $1\frac{13}{16}$" x $2\frac{1}{4}$"
Coil volts: 24 to 28 volts D.C.
Operate voltage: 18 volts minimum
Release voltage: 7 volts maximum
Contacts: 3-pole changeover
Contact Rating: 10 amps at 28 volts D.C. or 115 volts A.C.



SEALED RELAY T.10.C

Weight: 12.8 ozs.
Dimensions: $2\frac{3}{8}$" x 3" x $3\frac{1}{4}$"
Coil volts: 24 to 28 volts D.C. nom., 29 volts D.C. maximum
Operate voltage: 18 volts D.C. minimum
Release voltage: 7 volts D.C. maximum
Rating: Continuous
Contacts: 3-pole changeover
Contact rating: 10 amps at 28 volts D.C. or 115 volts A.C.



PYGMY POWER RELAY

New interchangeable dust proof relay designed for remotely controlled automation units. Plugs into any standard International octal valve base. Mechanical life over 10,000,000 operations.
Weight: $4\frac{1}{2}$ ozs.
Dimensions: $1\frac{3}{4}$" square by $2\frac{9}{32}$"
Switching current: 5 amps max. at 250 volts A.C.
Maximum surge current: 10 amps
Operate time: 8 milliseconds approx.
Release time: 7 milliseconds approx.
Coil voltage: 240 volts standard. 6, 12, 24, 48, 60, 110 volts either A.C. or D.C. also available.

AIRCRAFT COMPONENTS DIVISION · THORN ELECTRICAL INDUSTRIES LTD., GREAT CAMBRIDGE ROAD ENFIELD MIDDLESEX TEL: ENFIELD 5353

Thorn

ARCHDALE

"Pre-select"

FOR GREATER OPERATING SPEEDS —FASTER PENETRATING CAPACITY

Shown in use at The Electric Construction Co. Ltd., Wolverhampton, this ARCHDALE mechanical 'Pre-select' is fully meeting our claims to cut production times to a minimum. Not only are penetration rates as high as power and rigidity can make them, but much valuable time is saved by convenient pre-selection from 16 spindle speeds, at any time whether the spindle is running or stationary. Spindle speeds range between 15 and 1500 r.p.m. and the six rates of feed, selected by a single lever, between 24 and 400 R.P.I.

N.B. The illustration shows the drilling and spot facing of main fixing holes in end brackets for 250 B.H.P. electric motors.

JAMES ARCHDALE & CO. LTD., LEDSAM ST., BIRMINGHAM, 16

Telephone: EDGbaston 2276 - - - A member of the Staveley Coal & Iron Co. Ltd. Group

Sole Agents: ALFRED HERBERT LTD., COVENTRY. Telephone: 89221

CLASSIFIED ADVERTISEMENTS

AGENCIES · DIRECTORS · PARTNERSHIPS · SITUATIONS VACANT · EDUCATIONAL PATENTS · BUSINESS OPPORTUNITIES · MISCELLANEOUS · PUBLIC APPOINTMENTS BUSINESSES and PREMISES · TENDERS

Lineage Rate. 4/- per line of approximately 6 words. Minimum 16/-.

Inch Rate. 48/- per single column inch and *pro rata*. 12 lines to 1 inch. There are reduced rates (*i.e.*, not on a *pro rata* basis) for advertisements of ¼-page (12 column inches) and upwards, e.g., ¼-page £25 10s. ½-page £48. Full page £90.

AUCTION SALES · FOR HIRE · MACHINERY, etc., WANTED · SITUATIONS WANTED DRAWING AND DESIGN SERVICES · FOR SALE · SUB-CONTRACTING

Lineage Rate. 3/6 per line of approximately 6 words. Minimum 14/-.

Inch Rate. 42/- per single column inch and *pro rata*. 12 lines to 1 inch. There are reduced rates (*i.e.*, not on a *pro rata* basis) for advertisements of ¼-page (12 column inches) and upwards, e.g., ¼-page £22. ½-page £41 10s. Full page £78.

Series Discounts. For advertisements 1 inch and upwards. 6 insertions 5%. 13 insertions 10%. 26 insertions 15%.

Run-On and Semi-Displayed Styles. Both these styles are available for single column width advertisements of any depth up to 12 inches.

Displayed and Illustrated Styles. The minimum size for a Displayed advertisement is 3 inches single column, for an illustrated advertisement it is a ¼-page (12 column inches). Thereafter the sizes for both progress in steps 3 inches deep across 1, 2, 3 or 4 columns.

Use of Box Number. 2/- which includes forwarding of replies.

Copy Dates. "Run-on" and "Semi-displayed" advertisements by noon Tuesday for publication on Friday same week. "Displayed" and "Illustrated" advertisements by noon Friday for publication on following Friday. All advertisements three days earlier if proofs are required.

Advertisements for publication should be addressed to:—**Classified Advertisement Dept., "The Engineer", 28 Essex Street, Strand, London, W.C.2.**

Urgent advertisements may be telephoned to CENtral 6565.

PUBLIC APPOINTMENTS

CORPORATION OF GLASGOW—EDUCATION DEPARTMENT

FURTHER EDUCATION

STOW COLLEGE OF ENGINEERING

HEAD OF DEPARTMENT

Applications are invited for the full-time post of HEAD OF DEPARTMENT of Electrical Engineering at this College. The Department offers courses leading to the Higher National Certificate in Electrical Engineering and to the Final and Full Technological Certificates of the City and Guilds of London Institute in the subjects of Radio and Television Servicing and Electrical Installation respectively.

The essential qualifications are: A University Degree with first or second class honours in Electrical Engineering, approved industrial experience, and full-time teaching experience in a Further Education establishment. Corporate membership of the Institution of Electrical Engineers will be considered an advantage. The successful applicant will require to undertake a measure of evening class teaching and/or supervision.

The post is Grade I in terms of the Teachers' Salaries (Scotland) Regulations, 1956, and the appropriate salary scale is £790–£1345. To this would be added a responsibility payment of £360. Placing on the scale can be given for approved teaching and/or industrial experience. An addition of £55 is payable for approved teacher-training.

Forms of application may be obtained from the Director of Education, 129, Bath Street, Glasgow, C.2, to whom completed forms should be returned not later than 4th August, 1958.

WILLIAM KERR,
Town Clerk.

E7977

LOUGHBOROUGH COLLEGE OF TECHNOLOGY

DEPARTMENT OF WORKSHOP TRAINING AND PRACTICE

SHOP SUPERINTENDENT

Applications are invited for the position of MACHINE SHOP SUPERINTENDENT. The person appointed will be responsible for the practical instruction of full-time engineering students in Engineering Workshop Production Processes and for production in a machine shop, which contains milling, slotting, planing, shaping and gear cutting machines.

Applicants should hold good qualifications in machine shop engineering or production engineering, and good industrial experience is essential.

Salary will be paid according to the scale £650 by £25 to £1025 per annum. Starting salary within this range will be fixed according to experience and qualifications. The post is superannuable.

Application forms and further particulars may be obtained from the Registrar, to whom completed forms should be returned as soon as possible. (In reply please quote 23/C). E8059

COUNTY BOROUGH OF EAST HAM

ASSISTANT ENGINEER (MECHANICAL) GRADE II

£725–£845

London weighting is paid in addition. Salary in excess of the minimum may be paid according to qualifications and experience.

A subsistence allowance may be granted over a reasonable period to the person appointed if unable to obtain suitable housing accommodation, necessitating the maintenance of two homes.

Further details and application forms returnable by 1st August, 1958, from the Town Clerk, Town Hall, E.6. E8071

SURREY COUNTY COUNCIL

ASSISTANT HEATING ENGINEER

Applications invited for appointment of ASSISTANT HEATING ENGINEER, Special Grade £750–£1030 p.a., plus £30 p.a. London allowance. Must be A.M.I.H. and V.E. and experienced in heating and ventilating installations. Preferably experienced in testing boiler efficiencies.

Full details, present salary and three copy testimonials, to County Architect, County Hall, Kingston, as soon as possible. E7921

LOUGHBOROUGH COLLEGE OF TECHNOLOGY

DEPARTMENT OF ELECTRICAL ENGINEERING

LECTURER

Applications are invited for the post of LECTURER in the Department of Electrical Engineering. Applicants should be fully qualified electrical engineers, some lecturing experience would be an advantage. Commencing salary will be determined by previous educational and industrial experience, within the scale £1200 by £30 to £1350 p.a.

Both research and collaboration with industry are encouraged.

Further particulars and forms of application may be obtained from the Registrar. (In reply please quote 24/C). E8060

WEST RIDING COUNTY COUNCIL

CASTLEFORD, WHITWOOD MINING AND TECHNICAL COLLEGE

DEPARTMENT OF ENGINEERING AND BUILDING

LECTURER

Applications are invited from Graduates with suitable industrial and teaching experience for the post of LECTURER IN MECHANICAL ENGINEERING mainly for O.N.C. and H.N.C. Courses, and possibly Theory of Machines and Strength of Materials to A.2 level.

Salary in accordance with the Burnham Technical Report, £1200 by £30 to £1350 per annum.

Further particulars and applications obtainable from J. W. Davies, 2, Wesley Street, Castleford. E7988

BRITISH TRANSPORT COMMISSION

BRITISH RAILWAYS RESEARCH DEPARTMENT

SCIENTIFIC OFFICERS

British Railways Research Department have two vacancies for SCIENTIFIC OFFICERS Grade 2 in the Engineering Division at Derby.

Candidates should have a good degree but previous research experience not essential. Positions are for the study of:

(a) strength of materials, fatigue, etc.
(b) application of mathematics to the solution of engineering problems.

Salary £646–£956, according to qualifications or experience.

Superannuation and travel facilities.

Applications, stating age, experience, etc., to: Director of Research, British Transport Commission, British Railways Division, 222, Marylebone Road, London, N.W.1. E7971

LIVERPOOL REGIONAL HOSPITAL BOARD

ASSISTANT ENGINEER

ASSISTANT ENGINEER (Electrical) required on the staff of the Regional Engineer.

Applicants should have passed the Institution examination and be Graduate Members of the Institution of Electrical Engineers; be experienced in the preparation of specifications, drawings and estimates for distribution schemes, electrical installations in hospitals and buildings and be able to take details of existing installations and have a good knowledge of modern installation practice.

Salary scale: £700–£1015 per annum. Starting salary depending on age and previous relevant practical experience.

Applications, stating age, qualifications, experience, present and previous appointments, with names and addresses of three referees (two technical), to reach me at 55, Castle Street, Liverpool, 1, by 5th August, 1958.

VINCENT COLLINGE,
Secretary to the Board.

E7986

PUBLIC APPOINTMENTS

GHANA INDUSTRIAL DEVELOPMENT CORPORATION

PROJECT OFFICERS (INDUSTRY)

Applications are invited for two vacant posts with the above Corporation.

Candidates should have served an indentured apprenticeship or have had at least seven years' practical experience in one or more of the manufacturing industries embracing chemical engineering, and should subsequently have held responsible technical or supervisory posts. Ability to undertake market research and to assess the material, plant and labour requirements for new industries, and to supervise the layout and installation of machinery, &c., is required. Membership of a recognised Engineering Institute or a H.N.C. is essential. Candidates should also be able to appreciate product design, make drawings and write clear, concise reports.

Initial salary will be fixed between £1250 and £1500 per annum, according to qualifications and experience, &c.

Furnished accommodation at rates £60–£75 per annum. Contract period eighteen months with option for extension. Successful applicant will be required to join Corporation's Provident Fund, employee's contribution being calculated at 7½ per cent. and employer's at 17½ per cent. of salary.

An officer recruited overseas would receive passages for himself, wife and up to three children, below the age of 18, paid leave at the rate of seven days per month and outfit allowance of £30. An interest-free transport loan and other generous allowances are available.

Apply, stating age, qualifications and experience, to the Director of Recruitment, Ghana High Commissioner's Office, 13, Belgrave Square, London, S.W.1. E7981

CENTRAL ELECTRICITY GENERATING BOARD

ELECTRONIC DIGITAL COMPUTING SERVICE

CHIEF ASSISTANT ENGINEER

CHIEF ASSISTANT ENGINEER required in the System Planning Branch of the Planning Department at London Headquarters, S.E.1, to be responsible to the System Planning Engineer for the organisation and development of the Electronic Digital Computing Service. The Computing Section will be required to deal with a wide range of engineering and statistical problems, and applicants should have had previous operational and management experience in this field and have an interest in computer design.

Corporate Membership of the Institution of Electrical Engineers and/or a University Degree in Physics or Mathematics would be an advantage.

Salary within scale £2360–£2560 p.a.

Applications, stating age, qualifications, present position and salary, should be forwarded to S. S. Scott, Chief Personnel Officer, Central Electricity Generating Board, 24/30, Holborn, London, E.C.1, by 31st July. Mark envelopes "Confidential—ENR/201. E8014

CITY OF LIVERPOOL

WATER DEPARTMENT

ASSISTANTS

Applications are invited for the appointment of two ASSISTANTS (CIVIL ENGINEERING), (a) for the Vyrnwy Aqueduct and Works, under the Resident Engineer, Oswestry, (b) for the Drawing-Office Staff, Liverpool. Salary £575–£1030 per annum, according to qualifications and experience (A.P.T. I—Special N.J.C. Scale).

Applicants must either have been trained as a civil engineer and have passed Parts I and II of the Examination of the Institution of Civil Engineers (or hold the necessary exempting qualifications), or hold a suitable Degree of a British University. Experience in the construction or design of works of water supply an advantage.

Application forms (returnable by 31st July, 1958) from the Water Engineer, 55, Dale Street, Liverpool, 2. The appointments are superannuable and subject to the Standing Orders of the City Council. Canvassing disqualifies.

THOMAS ALKER,
Town Clerk.

(J.5266) E8000

PUBLIC APPOINTMENTS

CITY OF PLYMOUTH

APPOINTMENT OF SPECIAL STAFF FOR BRIDGE DESIGN AND CONSTRUCTION

Applications are invited for the following appointments:

(1) SENIOR ASSISTANT ENGINEER, Grade A.P.T. V (£1175–£1325), to be engaged on the design and supervision of the construction of the proposed new Laira Bridge. This is a 500ft. long dual carriageway crossing of tidal water and involves deep foundations.

Applicants should be qualified Civil or Structural Engineers, with experience in reinforced and prestressed concrete design and also in deep foundation work.

It is anticipated that the appointment will, subject to satisfactory service, be for a period of 4 years, the first part of which will be spent on design and the preparation of contract documents and the remainder as a member of the resident engineer's staff.

(2) DRAUGHTSMEN, at a salary up to £800 per annum, according to qualifications and experience, to be employed on the preparation of drawings for the new Laira Bridge. The applicants should be quick, accurate draughtsmen, preferably with previous experience in the detailing of reinforced concrete.

It is anticipated that subject to satisfactory service, the appointment will last for a period of three years.

Age limit for both appointments 40 or 45 if already serving with a Local Authority. The appointments are subject to medical examination and the successful applicants will be required to contribute to the superannuation fund.

Housing accommodation, if required, will be made available and part of removal expenses refunded.

Applications on forms obtainable from me are returnable within 14 days of the appearance of this advertisement.

J. PATON WATSON, C.B.E., M.I.C.E.,
City Engineer and Surveyor.

The Guildhall,
Plymouth. E7982

ATOMIC WEAPONS RESEARCH ESTABLISHMENT

ALDERMASTON, BERKS

ENGINEER (MAIN GRADE)

ENGINEER (MAIN GRADE) required by the Atomics Weapon Research Establishment, Aldermaston, Berks, to be responsible on shift for the operation of "Herald" 5MW Light water moderated research reactor at present under construction, and assist in initial commissioning.

A recognised engineering apprenticeship required and A.M.I.Mech. or E.E. or equivalent qualifications. Experience in the design, construction or operation of research reactors, or a similar highly instrumented continuously operating plant an advantage. Training where necessary will be given.

Salary: £1300–£1740 p.a.

Contributory Superannuation scheme. A house or assistance towards legal expenses on house purchase will be available for married officers living beyond daily travelling distance.

Postcards for application forms to the Senior Recruitment Officer at above address. Please quote ref. 1899/25. E7970

CIVIL SERVICE COMMISSION

SENIOR SCIENTIFIC OFFICERS (a): SCIENTIFIC OFFICERS (b)

Pensionable posts for men and women in major Scientific fields, including Meteorology and Geophysics (frequent overseas surveys).

A few vacancies for BIOLOGISTS, including specialised posts in Taxonomy of Invertebrate Animals, Fugus Systematics, and one post for a TAXONOMIC BOTANIST (Pteridophyta). Also one post in Home Office for MATHEMATICIAN/PHYSICIST to work on Civil Defence problems.

Qualifications: Normally First or Second Class Honours Degree in Science, Mathematics or Engineering, or equivalent attainment; additionally, for (a), at least 3 years' relevant (e.g. post-graduate) experience.

Normal age limits: (a) between 26 and 31; (b) between 21 and 28, with extensions for regular Forces service and Overseas Civil Service.

London salaries (men): (a) £1190–£1410; (b) £635–£1110. Five-day week generally.

Write, Civil Service Commission, 30, Old Burlington Street, London, W.1, for application form, quoting (a) S.53/58; (b) S.52/58. E7989

PUBLIC APPOINTMENTS

AUSTRALIA

STATE ELECTRICITY COMMISSION OF VICTORIA

CHEMICAL STAFF

The State Electricity Commission of Victoria seeks applications from INDUSTRIAL CHEMISTS of A.R.I.C. standard, with appropriate experience, for appointment to the staff of its high pressure steam power stations.

The Commission is constituted as a semi-government authority by Act of Parliament and is one of the largest electricity supply authorities in the Commonwealth of Australia, and is the largest producer of fuel with brown coal and briquette enterprises in the Latrobe Valley. It has a capital investment of approximately £A250 million, with an annual revenue of £A36 million.

The major steam stations are situated in the Latrobe Valley approximately 90 miles east of Melbourne, and the rapid expansion of the Commission's system involves the construction in this area of additional steam power plants of up to 1000MW capacity burning pulverised brown coal.

Facilities in this rapidly developing area include excellent schooling, shopping and sporting facilities, subsidised medical and hospital services and the other modern amenities of urban areas.

Salaries for the different grades appropriate to the applicant's qualifications and experience are :

Chemist, Grade I, up to £A1586
Chemist, Grade II, from £A1638 to £A1742
Chemist, Grade III, from £A1795 to £A1899

} These salaries include cost of living adjustment of £A490 per annum

Applicants for Grades 2 and 3 must have had experience of power station chemistry in high pressure steam plants or in research organisations working on problems associated with the operation of such plants.

Appointees and their families can be nominated and transported to Australia under the Commonwealth Government's Migration Scheme, details of which can be obtained from officials at Australia House, The Strand, London. Suitable housing for rental will be made available immediately to married appointees, and good hostel accommodation at a reasonable tariff will be available for single appointees.

Married appointees will be reimbursed at the expiration of six months' satisfactory service an amount of up to £A150, upon production of necessary receipts, in respect of removal of household furniture and effects.

Further details may be obtained on application to the Staff Superintendent at the address mentioned below.

Arrangements will be made for representatives of the Commission to interview selected applicants in England.

Applications, giving full details of qualifications, experience and war service (if any), stating date of birth and accompanied by copies of testimonials, should be submitted not later than 23rd August, 1958, to the Secretary—

STATE ELECTRICITY COMMISSION OF VICTORIA
22–32, William Street, Melbourne, C.1,
Victoria, Australia. E7925

CENTRAL ELECTRICITY GENERATING BOARD

SENIOR ASSISTANT ENGINEER (BOILER PLANT)

Applications are invited for the appointment of SENIOR ASSISTANT ENGINEER (BOILER PLANT) in the Planning Department at Headquarters, Bankside House, S.E.1, to conduct investigations into both the economic and design aspects of large future boiler plant installations for high pressures and temperatures and their major ancillary equipment with particular respect to chemical engineering considerations.

Candidates should preferably be Corporate Members of the Institution of Mechanical Engineers, or the Institution of Chemical Engineers, and have experience in the manufacture or design of boilers for chemical plant.

Salary within £1435–£1795 p.a.

Application forms, obtainable from S. S. Scott, Chief Personnel Officer, Central Electricity Generating Board, 24/30, Holborn, E.C.1, should be completed and returned in envelopes marked "Confidential—Ref. ENR/196" by 5th August. E7996

NORTH EAST METROPOLITAN REGIONAL HOSPITAL BOARD,

11a, PORTLAND PLACE, W.1

SENIOR ASSISTANT ENGINEER (MECHANICAL)

Applicants must be Corporate Members of the Institution of Mechanical Engineers, unless professionally graded in the National Health Service, and should possess experience in a senior capacity in the design of boiler plants, steam, heating, hot water and ventilating systems, and have a sound knowledge of all associated mechanical equipment, although not necessarily in the field of hospital engineering. Experience of large-scale laundry equipment an advantage.

Salary £1010 by £30 (5) by £35 (1) to £1195 per annum, plus London weighting £50.

Applications, giving age, present salary, qualifications and experience (with dates), together with the names of two referees, should be sent to the Secretary, North East Metropolitan Regional Hospital Board, 11a, Portland Place, W.1, within 14 days. E8070

SURREY COUNTY COUNCIL

HIGHWAYS AND BRIDGES DEPARTMENT

APPOINTMENTS

Surrey County Council Highways and Bridges Department have vacancies for :—

(a) CIVIL ENGINEERS.
Grades A.P.T. "Special," IV and V.
Appointments provide first-class experience in Bridge Design, Road Lay-out and construction.

(b) ENGINEERING ASSISTANTS.
Grades A.P.T. I and III.
Appointments provide suitable experience for those wishing to proceed to a professional qualification.

SALARY RANGES
(a) between £750 and £1325 per annum, and
(b) between £575 and £1025 per annum, plus London Allowance.

Particulars and forms of application returnable by 2nd August, 1958, from County Engineer, County Hall, Kingston-upon-Thames. E8007

CENTRAL ELECTRICITY GENERATING BOARD

HEADQUARTERS

CIVIL ENGINEERING DRAUGHTSMEN

Central Electricity Generating Board Headquarters have vacancies for CIVIL ENGINEERING DRAUGHTSMEN—Senior Draughtsmen, £800–£910 p.a. ; Draughtsmen, £635–£755 p.a. Starting salary within these ranges, according to experience.

This year's holiday arrangements honoured. Permanent pensionable appointments.

Canteen, sports and social club.

Applications in writing to, or application forms can be obtained from, S. S. Scott, Chief Personnel Officer, Central Electricity Generating Board, 24/30, Holborn, London, E.C.1, or by 'phoning WATerloo 2011, Ext. 434. Please quote reference ENR/195. E7997

MILFORD CHEST HOSPITAL, GODALMING, SURREY

ASSISTANT ENGINEER

ASSISTANT ENGINEER required. In addition to supervisory duties, person appointed will be required to assist in general maintenance work. Lancashire boilers with electrical generating installation and all usual hospital services and equipment. House with central heating available in hospital grounds at an inclusive rent, at present £1 8s. 10d. per week. Salary scale £525–£645 per annum. Contributory pension scheme.—Apply, giving names of referees to Group Secretary, not later than 20th August, 1958. E8008

NATIONAL COAL BOARD

DURHAM DIVISION

AREA CENTRAL WORKSHOPS MANAGER

Applications are invited for the above post at No. 2 Area Central Workshops, near Houghton-le-Spring, Co. Durham.

The appointment will be in the salary range £1050/£1600, and the starting salary will be in accordance with the qualifications and experience of the successful candidate.

The workshops employ about 600 men and are engaged mainly on the overhaul and repair of electrical and mechanical coal mining plant and machinery.

Candidates should have a general engineering background and preferably have some knowledge and experience of mining plant and equipment. Experience in the heavy repair of steam and diesel locomotives is essential, together with a knowledge of iron and brass foundry technique and the repair of wagons to main line standard. They must be capable of supervising the overall working and administration of the shops to achieve and sustain the maximum throughout of planned overhaul and jobbing work and of maintaining the required standards of workmanship and good personnel relationships. The possession of a Higher National Certificate in Mechanical and/or Electrical Engineering or equivalent is essential. Membership of an appropriate professional Institute or Association will be an advantage.

Apply, within 7 days, quoting SG/290/1(78), and giving full details of age, education, qualifications and experience, to Divisional Chief Staff Officer, National Coal Board, 7, Side, Newcastle upon Tyne, 1. E7994

TENDERS

SHEFFIELD CORPORATION WATER DEPARTMENT

CONSTRUCTION OF OAKS WATER TOWER

TENDERS are invited for the CONSTRUCTION of a REINFORCED CONCRETE WATER TOWER of 300,000 gallons capacity on land at Oaks Park, Norton Lane, Sheffield.

Tenderers must be able to show that they have had considerable experience in the construction of reinforced concrete water retaining structures above ground level.

The drawings and contract documents may be inspected without charge on application to the undersigned, from whom contractors desirous of tendering may obtain the drawings, specification, bill of quantities and conditions of contract, on deposit of £5 (Five Pounds), which will be refunded on receipt of a bona-fide Tender, and return of all documents.

Tenders are to be delivered in the envelope provided to the Town Clerk, Town Hall, Sheffield, by 10 a.m. on Saturday, 30th August, 1958.

The Water Committee do not bind themselves to accept the lowest or any Tender.

J. NOEL WOOD, M.I.C.E.,
General Manager and Engineer.
Waterworks Office,
Town Hall,
Sheffield, 1. E8058

EDUCATIONAL

A.M.I.MECH.E., B.Sc., City and Guilds, etc. Guarantee Postal Courses for all Exams., and Technical Divisions from Elementary to Degree standard. Approximately 95 per cent. successes. 144-page prospectus free on request.—B.I.E.T. (Dept. 22), 29, Wright's Lane, London, W.8. E114 x

SITUATIONS VACANT

APPLICANTS ARE ADVISED TO SEND COPIES, NOT ORIGINALS, OF THEIR TESTIMONIALS UNLESS OTHERWISE REQUESTED.

A FIELD ENGINEER is required by a company engaged in the manufacture of medium/heavy engineering products in the North West of England. Applicants for this important post must be first-class engineers, fully experienced in the control of labour, and must have held a position in which they have been in complete charge of all field activities for their company. The successful candidate will require to supervise installations of all machinery after factory tests, and to organise field labour and materials for the satisfactory operation of equipment on customers' premises. Please give full details of age, qualifications, experience, present salary and salary required. —BOX No. E8072, "The Engineer." A

ASSISTANT QUALIFIED ENGINEER required aged 32–36. Should be conversant with steam, refrigeration and electrical installations. Previous brewery experience an advantage. Apply in writing, stating age, qualifications and present salary to Staff Director, Truman's Brewery, Spitalfields, London, E.1. E1996 A

CHIEF MECHANICAL ENGINEER.—Large Opencast Mining Company require in SIERRA LEONE, professionally qualified Engineer with experience in responsible charge. Duties include responsibility for mechanical and electrical work connected with extensive earth-moving machinery, belt conveyors, power houses, workshops, &c. Age not under 35. Commencing salary, £3000 per annum, plus 5 per cent bonus, plus, for married man, passage or separation allowance of £10 per month and £5 per month for each child. 15-month tours followed by liberal leave on full salary in U.K. Return passage paid. Free furnished quarters and medical attention. Contributory pension scheme with retirement at age 55. Life assurance and dependants income schemes.—Write, giving full details experience, stating age, married or single, to SIERRA LEONE DEVELOPMENT CO., LTD., Dept. C4, City-Gate House, Finsbury Square, E.C.2. E7987 A

SITUATIONS VACANT

APPLICATIONS ARE INVITED for the following appointment at the CLAYDON, SUFFOLK, Works of THE BRITISH STEEL PILING CO., LTD.:—

SENIOR DESIGNER-DRAUGHTSMAN (minimum qualifications H.N.C. or equivalent).

Age group 28–35 years. Candidates should be capable of accepting responsibility for complete projects.

THIS APPOINTMENT IS PERMANENT AND PROGRESSIVE IN AN EXPANDING ORGANISATION, and the successful candidate will be engaged on interesting work in connection with special crane type structures, hoisting machinery (steam, diesel, electric) and contractors' plant.

Contributory pension scheme in operation. Good canteen facilities. Salary in accordance with qualifications and experience. Holiday arrangements respected. The works are situated 15 minutes' bus ride from the centre of Ipswich. Applications to The Personnel Officer at the above address. E8012 A

APPLICATIONS ARE INVITED for a good position with a large manufacturer of Salt Glazed Goods in the Midlands. Candidates should possess a sound knowledge of engineering, together with experience of up-to-date manufacturing and burning techniques, if possible, 30–40 years of age. Drive, initiative, and keen control of labour are factors which are desired and the capability of absorbing new techniques in the heavy clay industry. Good salary, Superannuation Scheme, and house available. Please reply fully in first instance, in strict confidence.—BOX No. E1994, "The Engineer." A

CONTRACTS MANAGER required for railway and civil engineering firm. Applicants must be qualified civil engineers experienced in railway design and construction, well versed in contract procedure and capable of meeting and dealing with the project engineers of the nationalised industries and with consultants. The position is an executive one and involves controlling contracts and site personnel in various parts of the country. Initiative and drive are essential, and the appointment offers excellent scope, good salary and incentive bonus to the successful applicant. Applications, which will be treated in the strictest confidence, should state age, qualifications, experience in detail, and indication of salary required.—Write, General Manager, Eagre Construction Co., Limited, East Common Lane, Scunthorpe (telephone No.: Scunthorpe 4513). E8073 A

DE HAVILLAND PROPELLERS, LIMITED,

require a

SENIOR ENGINEER

to be responsible for the design of novel features associated with LONG-RANGE BALLISTIC MISSILE ground equipment. Preference will be given to applicants who have the equivalent of an Engineering Degree or A.M.I.Mech.E., and a wide experience of the standard structural steel code of practice, as applied to bridge and crane design.

SENIOR ENGINEER

As a result of expansion of our work at Stevenage, we shall need a Senior Engineer to assist in the setting-up and eventually to take charge of a Development and Acceptance Test Facility.

He should have a Degree or equivalent qualifications and experience of small high-precision instruments, preferably including gyros and analogue computers.

Ability to accept responsibility and to co-operate with others will be considered as important as technical qualifications for this position. The successful candidate will start at London office, but will be expected to take up permanent quarters at Stevenage before the end of this year.

SENIOR ENGINEER

In our Production Engineering group, we require an Engineer to take charge of a group of engineers working on circuit evaluation and tolerancing. The group operates as a combined theoretical and practical laboratory team.

Candidates should have had previous experience of this kind of work and a Degree or equivalent qualification is desirable, but not essential.

These appointments are in our London office, and salary commensurate with experience and qualifications. Please write, giving full details, to the Personnel Manager (ref. CTT118) :—

DE HAVILLAND PROPELLERS, LIMITED, CONQUEST HOUSE, 37/39, JOHN STREET, THEOBALDS ROAD, LONDON, W.C.1.

E8075 A

DESIGNER DRAUGHTSMAN (MECHANICAL) required for Research and Development Team engaged on interesting development work in connection with special structures and diesel and steam operated plant. Minimum qualifications, O.N.C. Age group 24–30 years. The appointment is permanent and progressive in an expanding organisation. Contributory Pension Scheme and good canteen facilities. Salary in accordance with age, qualifications and experience. The works are situated 15 (fifteen) minutes 'bus journey from the centre of Ipswich.—Applications to Personnel Officer, THE BRITISH STEEL PILING CO., LTD., CLAYDON, SUFFOLK. E7950 A

DESIGN ENGINEER

UNILEVER LIMITED at their Food Research Department require a DESIGN PROJECT ENGINEER of Graduate Membership of the Institution of Mechanical Engineers to work on Food Engineering projects. Each project is handled by a small team in which the man appointed would be the engineering member. The problems are diverse and concerned with the development of new techniques of food harvesting, processing and packaging. A sound works and drawing office experience would be helpful but imagination is necessary for the work. Basic unit operation knowledge would be an advantage.

An appropriate salary would be paid, together with superannuation fund benefits.

Applications to : The Staff Officer (Ref. IDM 35), Unilever Limited, Food Research Department, Colworth House, Sharnbrook, Bedford. E7974 A

STRUCTURAL ENGINEERING DRAUGHTSMEN

required by

MINISTRY OF WORKS

for employment in London, Scotland and Provinces on design and detailing of reinforced concrete or structural steelwork.

SALARY RANGE £550 (age 21) to £870 p.a., London (slightly less elsewhere). 5-DAY WEEK. 3½ WEEKS' ANNUAL LEAVE INITIALLY.

STARTING PAY ACCORDING TO AGE, QUALIFICATIONS AND EXPERIENCE.

GOOD PROSPECTS OF PROMOTION WITH SALARIES OF £1015 p.a. AND ABOVE.

OPPORTUNITIES FOR PERMANENT POSTS LEADING TO PENSIONS (NON-CONTRIBUTORY).

Possession of O.N.C. or equivalent an advantage.
Interviews at Regional Offices where possible.

APPLICATIONS.—State age, training and experience to Chief Structural Engineer, Ministry of Works, Room 404, Abell House, John Islip Street, S.W.1.

E7717

Classified Advts. continued on page 122

SITUATIONS VACANT

DESIGN-DRAUGHTSMAN required by general engineering company, 30 miles south of London, experienced in laying out and detailing process plant and machinery for the chemical and allied trades. Small drawing-office, interesting and varied work for capable man. Send full details, age, experience, &c., and salary required.—BOX No. E2002, "The Engineer." A

DESIGN ENGINEER capable of producing practical ideas giving guidance to draughtsmen and being responsible for finished drawings and specifications, required by large modern firm producing Pressure parts for varying services and temperatures. A knowledge of combustion and light foundry work an advantage. Drive, initiative and good technical qualifications essential. Excellent prospects for right man.—State age, experience and present salary.—BOX No. E7953, "The Engineer." A

DRAUGHTSMAN, experienced in the design and development of agricultural machinery; opportunities for advancement for suitable applicant.—BOX No. E1982, "The Engineer." A

DRAUGHTSMAN, with experience on design of hydraulic presses and castings.—Apply, Modern Mechanisation, Ltd., 52, Bounds Green Road, London, N.11. E1988 A

DRAUGHTSMEN.—The National Smelting Co., Ltd., Avonmouth, offers good opportunities to experienced Mechanical Draughtsmen for design and detail work in connection with metallurgical and chemical plant and equipment. A wide variety of work is offered and good promotion prospects exist for young men holding or prepared to obtain H.N.C. or equivalent. All appointments are permanent and pensionable, with excellent working conditions and amenities.—Write to Personnel Manager for application form, quoting ref. DN8/TE. E8010 A

ELECTRIC ARC MELTING SHOP SHIFT MANAGER for large steelworks in the Midlands. Applicants, aged 30–40, should have a metallurgical training with practical experience in an Electric Melting Shop. Salary according to qualifications and experience. Pension and free life assurance scheme in operation. Full details of age, experience and qualifications to BOX No. E7975, "The Engineer." A

ELECTRICAL ENGINEER, Graduate, with heavy electrical experience, and strong interest in electronics, required. The work is varied and interesting, ranging from layouts of heavy industrial systems to the development of electronic equipment. Salary £1000–£1500 per annum, depending on age and experience. A flat is available.—Apply, giving full details, to The Chief Engineer, Michael Nairn and Co., Limited, Kirkcaldy, Fife. E2004 A

ENGINEER graduate for Project and Development work required. The work involves the development of special machines and the planning and commissioning of complete projects. Applicants should be graduate engineers. Salary £800–£1200 per annum, depending on age and experience.—Apply giving full details to The Chief Engineer, Michael Nairn and Co., Ltd., Kirkcaldy, Fife. E2005 A

ENGINEER with practical experience of Bottling Store installations required for four–five years, to cover period of rebuilding. Age 40–50.—Apply in writing to Staff Director, Truman's Brewery, Spitalfields, London, E.1. E1997 A

ENGINEERING CONSULTANTS require for their London Office a professionally qualified CHEMICAL DESIGN ENGINEER to take control of Chemical and associated plant Department. Duties entail project development and design layouts and also supervision of site duties. This is a senior executive appointment and candidates are invited to forward applications outlining history of experience and qualifications and positions held to date together with details of corresponding scales of emoluments for each appointment.—BOX No. E7935, "The Engineer." A

ERECTION ENGINEER.—Suitably experienced man required to take charge of erection of aerial ropeways abroad. Excellent climate and conditions; 18 to 24 months' initial contract.—BOX No. E1968, "The Engineer." A

FRANCE. Young qualified ENGINEER required by manufacturers of rubber containers. Fluent command of English and French essential. Successful applicant will be required to work in Paris.—Reply to BOX No. E7996, "The Engineer." A

HEATING INTERMEDIATE DRAUGHTSMAN required in London accustomed to design with minimum supervision. Salary up to £1000 per annum to right man. Permanent position with pension facilities and excellent prospects.—Write in confidence, stating full details of age, experience and past employers to Ellis (Kensington), Ltd., Kendrick Place, London, S.W.7. E2001 A

K. S. PAUL (MOLYBDENUM DISULPHIDE), LTD., Park Royal Road, N.W.10, require for Technical Sales Department APPLICATION ENGINEER, to advise customers on difficult lubrication problems. London based. Applicant must be keen, energetic, loyal. Excellent prospects for advancement.—State salary, experience, age, in confidence, to Managing Director. E1974 A

LEADING INSURANCE COMPANY invites applications from Mechanical Engineers not over 35 years of age for appointment as ENGINEER SURVEYOR in London and surrounding districts. Applicants should have served an apprenticeship and had subsequent experience with a General Mechanical Engineering Company or Companies and should be Corporate Members of the Institution of Mechanical Engineers. Progressive salary scale commencing at £735 rising to £1060 over 22 years, plus expenses and allowances. Non-contributory Pension Scheme and other Staff Schemes. Apply in own handwriting.—BOX No. E8602, "The Engineer." A

LONDON ENGINEERING FIRM, specialising in auxiliaries for boiler plant, require young ENGINEER for carrying out experimental work, under direction, alternating with drawing-office work. At least 2 years' drawing experience desirable. Interesting and progressive job for the right man.—Particulars and requirements to Metropolitan Engineering Co., Ltd., 47, Whitechapel High Street, London, E.1. E8074 A

LIGHT ENGINEERING FIRM near Nottingham require CHIEF TOOL DESIGNER, who has previous experience in connection with press work fabricating metal products, and is familiar with machine shop practice. Please reply, giving full particulars of age, education and experience.—BOX No. E1991, "The Engineer." A

MAINTENANCE ENGINEER. Preferable with building experience for medium size company West London. Wood and Allied Trades. Applicants interested in hard work and achievement rewarded—others need not apply. Salary according to ability, experience and personality. Minimum £620 p.a. Practical journeyman and sound supervisor required. Incentives/Bonus.—BOX No. E1983, "The Engineer." A

MECHANICAL ENGINEER. Gemec, Ltd. have a vacancy at their Polyethylene Plant in Grangemouth for a Graduate in Mechanical Engineering. Industrial experience desirable but not essential as training will be given in all sections of the manufacturing process. Good prospects for advancement. There is a Contributory Pension Scheme.—Applications, including age and details of education and qualifications should be addressed to the Works Manager, Gemec, Ltd., P.O. Box 25, Grangemouth, Stirlingshire. E1998 A

PRODUCTION ENGINEER required by progressive light engineering company near Nottingham. This is a senior post offering considerable scope for capable man. He will be entirely responsible for all manufacturing methods, and have charge of technical staff. The company's plant includes press shop, machine shop, including automatics, and well-equipped toolroom. A good salary will be paid, commensurate with the responsibilities involved. Please reply in confidence, giving full particulars of age, education and experience.—BOX No. E1990, "The Engineer." A

RESIDENT ENGINEER required—experience r.c. and plant—for extension to Waterworks 75 miles from London.—Write L. G. Mouchel and Partners, 36–38, Victoria Street, Westminster, S.W.1. E2003 A

RESPONSIBLE SOILS ENGINEER required for road work in Nigeria by Contractor, for one or two tours of 15–18 months each. Opportunity for pioneer work in relatively undeveloped country. Good salary, kit allowance, free quarters. Paid leave at the rate of one month per six months of duty. Apply with full details.—BOX No. E7984, "The Engineer." A

SENIOR DRAUGHTSMAN, over 35, required by Midland firm to handle all mechanical and electrical details of contracts for pumps, pipework, control gear, &c. Some supervision experience necessary. Superannuation scheme available. Minimum starting salary £900.—BOX No. E7956, "The Engineer." A

SHELL-MEX AND B.P., LTD., have vacancies in their London Office for qualified ENGINEERS. Candidates should have had thorough training in workshops and possess either Corporate Membership of the Institutions of Civil or Mechanical Engineers or have passed parts A and B of one of these Institutions' examinations (or have qualifications entitling them to exemption from such examinations). Experience on pumps and pipelines or building construction will be advantageous. Starting salary commensurate with qualifications and experience. Excellent pension scheme.—Apply in writing giving full details of age, qualifications and experience to the Staff Manager, (Ref. 29/132) Shell-Mex and B.P., Ltd., Shell-Mex House, Strand, W.C.2. Second applications cannot be considered. E7983 A

SOUTH AFRICA.—Research Engineers are required by the National Mechanical Engineering Research Institute, C.S.I.R., Pretoria, in the following fields: Aerodynamics. Hydromechanics, Thermodynamics, Heat transfer. Minimum qualifications: B.Sc. in Engineering or equivalent. Salary in range £570–£1614 according to experience. Passage paid.—Apply further information: South African Scientific Liaison Office, Africa House, Kingsway, London, W.C.2. E8061 A

STRUCTURAL ENGINEER

required as
TECHNICAL SALES REPRESENTATIVE
in the London Area

Experienced, qualified Structural Steelwork Engineer, preferably M.I.Struct.E. or equal, with sound sales experience and good contacts with architects and consultants; also, sound design experience. This is a new position being created to maintain regular contact with existing connections in the London area and to considerably expand these contacts and resulting orders.

The company is one of a group establishing a general sales office in London. There are, therefore, good prospects for advancement for the right type of applicant.

The position calls for a man with drive, initiative and readiness to make every effort to ensure success. Applicants, aged 35/50, most likely to be suitable, but older men may be considered who have extensive connections. Remuneration not less than £1250 p.a. basic salary, plus commission on sales and reasonable expenses; car provided for general use.

Applicants should give full details of age, qualifications, past employers, positions held and experience. Applications will be treated in strict confidence and no approach will be made to previous employers without first consulting the applicant.

BOX No. E2000, "The Engineer." A

TECHNICAL ASSISTANT

Age about 25, for Design and Development work on light electro-mechanical products. Experience in fractional H.P. motors desirable and H.N.C. (Mechanical or Electrical) preferred. Salary up to £850 per annum.

The above vacancy is available with a large, progressive company some 65 miles from London.

Applications, giving full details of experience and qualifications, to Personnel Manager.—BOX No. E8069, "The Engineer." A

WORKS ENGINEER required for a public Company in Lancashire employing 1500 in works which is being extensively modernised.

The Works Engineer will be responsible for the construction and maintenance of buildings; installation, repair and maintenance of process plant; steam and power generation, and transport.

Candidates should have a degree or professional qualification in mechanical or electrical engineering, and have works engineering experience. Preferred age 30 to 35.

Please send brief details with application to BOX No. E7972, "The Engineer." A

STRUCTURAL STEELWORK FABRICATORS

Birmingham Area, require
PRODUCTION MANAGER

Experienced Structural Engineer required as Production Manager, age 30/40 years. This is a senior position and carries considerable responsibility. Applicants should have good general education and have served works and office apprenticeship in structural engineering. Preferably Member of an Engineering Institution, with reasonable knowledge of design of steel structures, sound experience and knowledge of methods and problems connected with manufacture.

Short period of training will be given to successful applicant, after which time he will be expected to co-ordinate work throughout the whole of the production departments, planning the sequence of work and organising general production programme to give maximum efficiency.

Academic qualifications not essential, but in view of the prospects of advancement they will be of distinct advantage. Sound experience, however, is absolutely essential.

Applicants should state age, where trained, previous employers, positions held, general experience, qualifications and salary required. All replies will be treated in strict confidence and no approach will be made to previous employers until the applicant has been consulted.

BOX No. E1999, "The Engineer." A

THE WORLD-WIDE HILTI SYSTEM requires men of calibre in London, Midlands, Sussex, Norfolk and North Wales. We offer steady employment, high earnings through salary, commission and expense allowances; very interesting and satisfying work with full possibility of continuous progress.

Conscientious and efficient work required and ability to approach people at every level on fastening problems.

The electrical and building trades are the main fields in which we offer important savings to our customers. Wide knowledge in these trades an advantage. Car essential.

Please send full details of background, salary and future plans, to:

The Product Manager,
UCAN DEVELOPMENT, LIMITED,
Dome Buildings, The Quadrant, Richmond, Surrey.

E8068 A

"VALOR"

invite written applications for the post of ASSISTANT TO PRODUCTION MANAGER on the mass production of Oil Burning Appliances. The post will lead to executive status.

A sound practical and technical background is essential, preferably with a degree or other professional qualification in Engineering, or kindred subject.

Age not exceeding 35 years.

Applicants must be resourceful, active and interested in production.

Give particulars of education, training, industrial experience, age and salary required to:

The Secretary,
THE VALOR COMPANY, LIMITED,
Bromford, Erdington, Birmingham, 24.

E8009 A

WORKS MANAGER

Applications for position of Works Manager are invited by a well-known firm of Engineers in the East Midlands engaged in the manufacture of high-class special machinery and general engineering.

Candidates should be between 35 and 40 years of age, having served a period as Works or Student Apprentice and have the qualification of Higher National Certificate in Mechanical Engineering or equivalent. Some experience in management and up-to-date methods is essential.

The appointment to commence mid-September or early October.—Write, giving details of age, experience and qualifications to BOX No. E7933, "The Engineer."

All applications will be treated in confidence.

A DEVELOPMENT ENGINEER

is required by a well-known group of companies to join a small team stationed at newly erected and specialised workshops in the Manchester area engaged in the development of manufacturing techniques at factories, both in this country and overseas. Candidates should be of A.M.I.Mech.E. status, with appropriate experience of plant and machine design, but consideration will be given to Graduate members. In other ways, qualities of initiative, application and creative ability are of paramount importance. A commencing salary of up to £1000 p.a. is offered, with membership of a non-contributory pension scheme. There is opportunity for promotion within the Group.

BOX No. E8003, "The Engineer." A

MSL

have been retained to advise on the appointment of a

DEVELOPMENT CHEMICAL ENGINEER

for the British subsidiary of an American company with wide interests in the pharmaceutical and chemical industries. The British company which is located in the East Midlands has the resources and is preparing for diversification with emphasis on industrial chemical processes.

In providing the ideas for profitable new projects the Chemical Engineer will make a positive and individual contribution to the company's future development. He will investigate markets and products in the United Kingdom and Europe and make regular liaison visits to the U.S. parent company.

He must have a degree or professional qualification in chemical engineering and have worked in a chemical process industry preferably petro-chemicals or plastics. It is essential that he should have a full understanding of the commercial application of his work.

Age 32–42; late thirties preferred. Starting salary not less than £2,500 with the usual benefits.

No information will be disclosed to our clients until candidates know their identity and have given permission after personal discussion. Please send brief details in confidence, quoting reference G.1098, to H. J. M. Campbell.

MANAGEMENT SELECTION LIMITED
17, Stratton Street, London, W.1.

E7980 A

K. & L. Steelfounders and Engineers, Limited

Makers of JONES MOBILE CRANES

One of the "600" Group of Companies

Wish to appoint a

METHODS DEVELOPMENT ENGINEER

for medium to heavy machining, fabrication and assembly operations.

Applicants should have experience in this class of work and ability to instruct operators on the shop floor. Additional experience of material handling and factory layout would be an advantage.

Salary will be commensurate with the importance of this position and the experience and ability of the successful candidate.

Assistance with housing can be considered.

Applications, in strict confidence, giving full details of education, training and experience to the Personnel Executive, Letchworth, Herts.

E7991 A

SITUATIONS VACANT

SENIOR DESIGN AND DEVELOPMENT ENGINEER

BRITISH OXYGEN GASES, Limited, require, for their Aircraft Equipment Works at Harlow, a Senior Design and Development Engineer.

Applicants must be capable of carrying projects from a basic specification through design and development, and must be able to exercise technical control in the production stage.

Applicant's present experience must be of a senior level in the precision equipment field, preferably airborne precision equipment, with the emphasis on engineering, design and development. A sound background of engineering or science is required, coupled with a minimum qualification of H.N.C., but a Degree would be preferred. A lively and enthusiastic approach to engineering problems is required.

A very good commencing salary is offered and the position is progressive. Rented accommodation is readily available at Harlow and consideration will be given to meet removal expenses, etc.

Write, stating full details of age, experience and qualifications, to **Personnel Manager, Spencer House, St. James's Place, London, S.W.1.**

E8067 A

SITUATIONS VACANT

MANUFACTURING SUPERINTENDENT

Wanted for

Electrical Switchgear Factory in Johannesburg

The factory produces modern types of 6·6/11kV oil circuit breakers, L.T. switchgear up to 660 volts, fuse gear, industrial control gear, etc., to British designs.

Applicants must have had experience in organising production of similar equipment in a modern factory in Britain and control of all grades of labour.

A knowledge of cost control and expenditure budgetting is essential.

Salary £130 per month, plus free passages for successful applicant and family.

The Company operates a contributory pension scheme.

Apply, giving age, training, past experience and other relevant details to :

The Secretary, A.E.I. Overseas Ltd.,
Crown House, Aldwych, London, W.C.2.

E7992 A

CADBURY BROTHERS LTD.

HAVE VACANCIES FOR

DRAUGHTSMEN

for plant design and layout work, with some works experience. The National, or Higher National Certificate, though not essential, would be an advantage. Five-day week, attractive working conditions, Pension Scheme. Provision of accommodation will be considered.

Apply in writing, stating age, qualifications, experience, and salary required, to :

CHIEF ENGINEER, CADBURY BROS., LTD., BOURNVILLE, BIRMINGHAM

E131 A

SENIOR DEVELOPMENT ENGINEER

to take charge of a Development Laboratory operating in conjunction with a Division manufacturing a very wide range of accessories for the electric supply industry. Candidates should be capable of directing laboratory staffs in all aspects of the development of new products, which entails pronounced powers of leadership, combined with original thought and technical ability.

Applications are accordingly invited from Engineers with a University Degree and several years' experience in the Engineering Industry, preferably in this type of work.

An attractive salary will be offered ; conditions of employment are excellent and there is good scope for further advancement.

Apply, Box No. E8066 "The Engineer."

DESIGN DRAUGHTSMEN

will have their skill rewarded by

Hotpoint

(an A.E.I. Company)

We pursue a major expansion programme and men who join our Domestic Appliance Design Team will soon realize the excellent potential for advancement.

Experience with Domestic Appliance is not essential but applicants should be familiar with light engineering practice. The work is challenging and interesting and only men with real ability and ambition should apply.

We will pay better-than-average salaries for better-than-average performance and will give assistance with housing and removal to suitable candidates who join this company in the pleasant country town of Peterborough.

Post the coupon below (2d. unsealed envelope) to the **Personnel Manager, Hotpoint Electric Appliance Co., Ltd., Crown House, Aldwych, London, W.C.2,** and hear more about the excellent prospects with this progressive company.

Please send me details of employment with Hotpoint.

Name .....

Address .....

.....

E7993 A

MSL have been retained to advise on the appointment of a

PRODUCTION DIRECTOR

(South Africa)

for a wholly owned subsidiary of an old established company having a high reputation in the design and manufacture of engineering equipment which has a world wide market. The subsidiary factory, which is in Johannesburg, was set up in the 1930's and at present employs approximately 300 in a modern plant of 40,000 sq. ft.

The appointment is a new one. The Production Director will be respons ble to the Managing Director for the executive management of the manufacturing organisation, and will act as his deputy during his absence.

Candidates, who should possess a degree or other professional qualification in mechanical engineering, must have a wide experience of production planning and works management in light/medium engineering industry, and have proved organising ability. A knowledge of heat treatment and metallurgy would be an added recommendation.

Preferred age 35–40. Salary £3,500–£4,500, according to experience, plus a car. Passage and removal expenses for the successful candidate and his family will be paid by the company.

No information will be disclosed to our clients until candidates know their identity and have given permission after personal discussion. Please send brief details in confidence, quoting reference G.1127, to M. B. Berks.

MANAGEMENT SELECTION LIMITED
17, Stratton Street, London, W.1

E8065 A

SITUATIONS WANTED

STRUCTURAL DETAILER DRAUGHTSMAN age 23, seeks overseas post. Five years' experience, including two years in South Africa. National Service completed.—Reply BOX No. E1992, "The Engineer." B

ENGINEER, B.Sc. (32), ex-R.A.F., four years' precision hydraulic design experience followed by four years as agricultural engineer in the tropics, seeks position ; preferably in original design field.—BOX No. E1993, "The Engineer." B

MISCELLANEOUS

TIME RECORDERS, Sales, Rentals, Service, Telephone Hop 2239.—Time Recorder Supply and Maintenance Co., Ltd., 157–159, Borough High Street, London, S.E.1. E110 I

PATENTS

SNUBBERS FOR CRANE BOOMS.—The Proprietors of British Patent No. 721,801 will grant Licences or will Sell the entire British Patent Rights.—Replies to Bromhead and Co., Chartered Patent Agents, 19/23, Ludgate Hill, London, E.C.4. E7999 H

PATENT NO. 730361, "Converting Oscillatory Motion to Uni-Directional Rotary Motion," for Sale or Licence.—Apply, Chatwin and Company, Chartered Patent Agents, 253, Gray's Inn Road, London, W.C.1. E2007 H

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COMPETITIVE STEELWORK DESIGNS, plans and detail drawings for all kinds of buildings and structures by experienced Structural Engineers. Quick service. HOLborn 2587. E1964 S

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23, Moorgate, E.C.2. (Tel. : MET 8001)
E8063 L

Classified Advts. continued on page 124

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E7192 MW

MACHINERY Etc. WANTED

WANTED, Machines of all Types. CASH PAID.
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WANTED

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COUNTY BOROUGH OF CROYDON

SALE OF GAS COMPRESSOR PLANT

OFFERS are invited for the PURCHASE of the following:

Belliss and Morcom Six-stage Compressor 100 c.f.m. to 5000 p.s.i.

62 h.p. Flameproof Motor by Lancashire Dynamo and Crypto, 3 ph., 50 c., 400–440V, 1470 r.p.m.

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Flameproof Condensers for Switchgear.

12 Main Storage Cylinders by Chesterfield Tube Co., each approx. 13ft. 10in. long by 21½in. o.d., water capacity 19 cu. ft. for storage at 5000 p.s.i., weight approx. 3½ tons each, and a quantity of high pressure piping and unions ¾in. o.d., compressor spares, pressure gauges, valves, springs, etc.

The plant may be viewed at the Sewage Disposal Works, Beddington Lane, near Croydon (THO 3080).

Form of offer can be obtained from Borough Engineer, Town Hall, Croydon.

Offers, in plain sealed envelopes, endorsed "Gas Compressor Plant," to be delivered to me by 12.0 noon on Thursday, 14th August, 1958.

E. TABERNER,
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E7973

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BESCO Heavy Universal Edging, Bending and Folding Machine, capacity 8ft. 2in. by 16 gauge, fitted with centre supporting leg to strengthen bottom bed; an angle stop is also fitted for repetition work; the machine is complete with one sharp edge blade only; blades are quickly interchangeable; an adjustable back gauge also supplied. Weight approximately 3100 lb.

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TURNER BROTHERS Type TB 20, Geared Open-Fronted Upright Power Press, with steel plate frame, arranged motor drive for 440/3/50, guards cover drive and gearing, complete with Udal automatic operator's safety guard, pressure exerted approximately 20 tons, stroke 4in., size of bed 24½in. by 16½in. Weight approximately 35 cwt.

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New Type SK.G.203, No. 4 size, Motorised Geared Open Ended Guillotine Shearing Machine, under-crank type, arranged motor drive for 400/440/3/50, capacity, mild steel 80¼in. by ¼in., length of blades 83½in., depth of gap in open ends 6in., treadle-operated clutch, weight approximately 40 cwt.

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E119 G

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E111 G

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TWW

FOUR UPSTROKE HYDRAULIC PRESSES, 20 tons capacity, stroke approx. 10in., daylight 22½in., platen size 12in., distance between push back rams 16½in., fabricated construction, bottom table moving in slides.

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TWO FRASER MONO RADIAL HYDRAULIC PUMPS Type OLS30, capacity 30 g.p.m. at 3300 p.s.i., direct coupled to Brush 75 h.p. slipring motors, mounted on combined baseplate.

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E218 G

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90-ton Electric Travelling Goliath Crane, 106ft. span, 72ft. lift, all lattice steel construction, electrics 400 volts, 3-phase, 50 cycles. Tested by Lloyds to 150 tons.

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E8005 G

"FIELDING" SINGLE COMPRESSION SCRAP METAL BALING PRESS

Size of box—72in. by 36in. by 32in. deep.
Depth of box when cover closed—18in.
Size of bale—36in. by 18in. by 10in. to 12in.
Weight of bale approximately 3 to 4 cwts.
Estimated output 20/22 bales per hour.
Preliminary pressing power, cover ram—208 tons
Specific pressure on material—5 tons per sq. ft.
Power of horizontal ram—208 tons.
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PUMP
Motor-driven high-speed oil pump capable of delivering:
40 g.p.m. at 1500 lbs. per sq. inch.
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50 h.p., 720 r.p.m. T.E.S.C. complete with 50 h.p. wall fixing starter, H.O. Oil immersed Star Delta.
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E7858 G

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E7998 G

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E213 G

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E7959 G

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60-ton Goliath, by Clyde, 40ft. span, 5-ton auxiliary; cab control, 400/3/50.
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Surplus Unused Ministry Cranes, mainly still packed. Drawings on request. Inspection invited. Bargain prices about one-third of New.

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E120 G

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E7969 G

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E8006 G

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RAILWAY MATERIAL.—Hunslet 0–6–0, 18in. by 26in. cyl.; Bagnall 0–4–0, 14in. by 22in.; 150 h.p. Stephenson Diesel Loco., fluid flywheel drive; Ruston 80/88 h.p. Diesel Loco., electric start, flameproof; Peckett 14in. by 22in. and 7in. by 12in. Steam Locos.; 3 miles 20 lb. Track, 24in. gauge bogies, turnouts, locos, &c.

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STORAGE TANKS.—300 cylindrical and rectangular up to 12,000 gallons, for oil and petrol, also sectional steel and cast iron up to 50,000 gallons.

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July 29-30	**Machine tools, textiles, and miscellaneous stores** including :—	M.O.S. Storage Depot, **Byley, Middlewich, Cheshire.** (Sale at New Islington Public Hall, Ancoats, Manchester.)	**J. H. NORRIS & SON** (Dept. L), 9, Albert Square, Manchester, 2. (Tel.: Blackfriars 8373.)
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August 26-29	**Machine tools, vehicles and miscellaneous stores**	M.O.S. Storage Depot, **Royal Arsenal, Woolwich, London, S.E.18.**	**FULLER, HORSEY, SONS & CASSELL** (Dept. L), 10, Lloyds Avenue, London, E.C.3. (Tel.: Royal 4861.)
September 3-4	**Machine tools and miscellaneous stores**	Technical Stores Depot, **Old Dalby, Melton Mowbray, Leicestershire.** (Sale at Melton Mowbray.)	**SHOULER & SON** (Dept. L), 1, Norman Street, Melton Mowbray, Leics. (Tel.: 81.)

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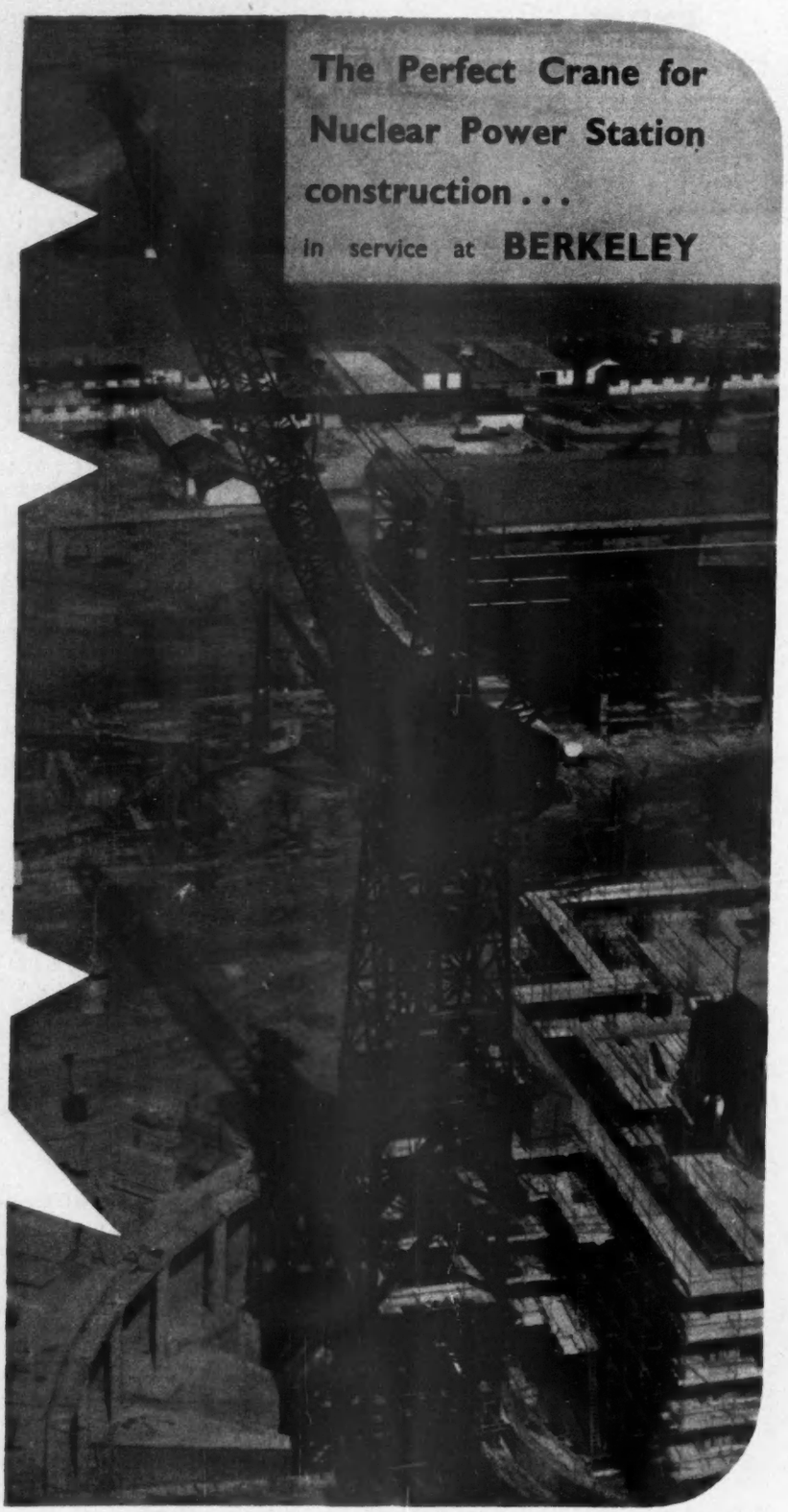

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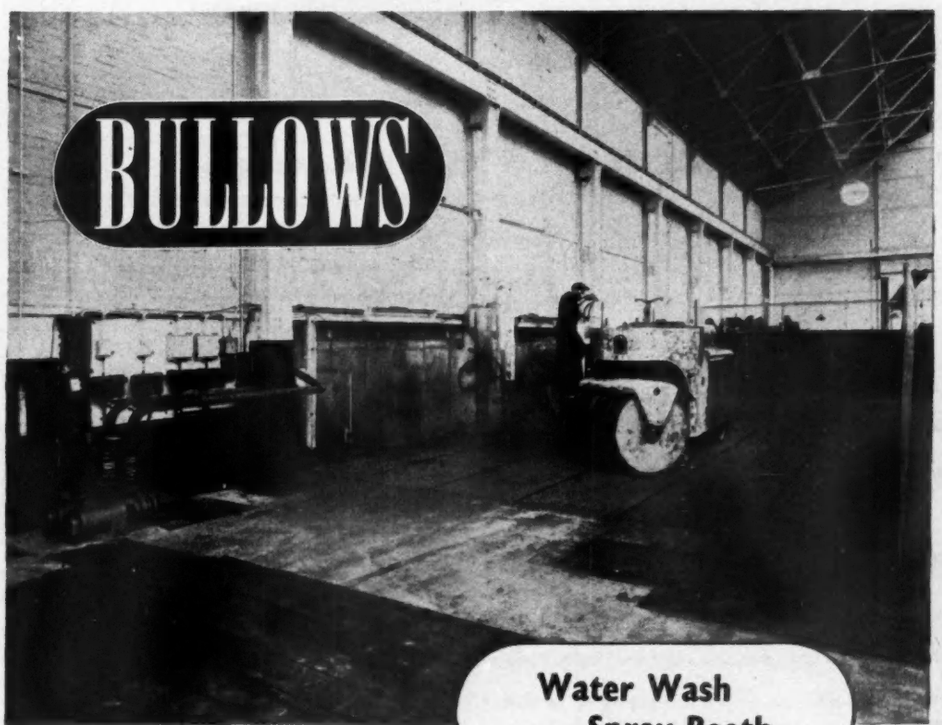

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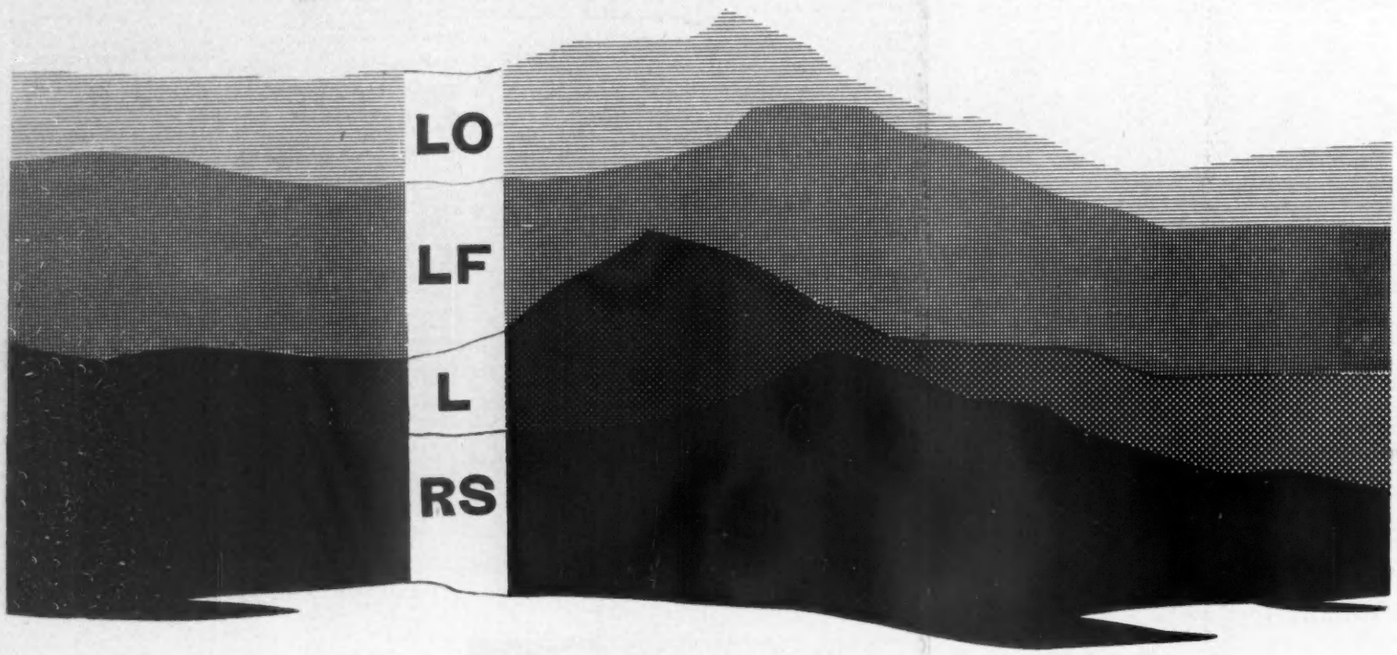

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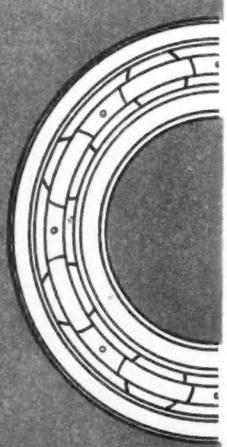

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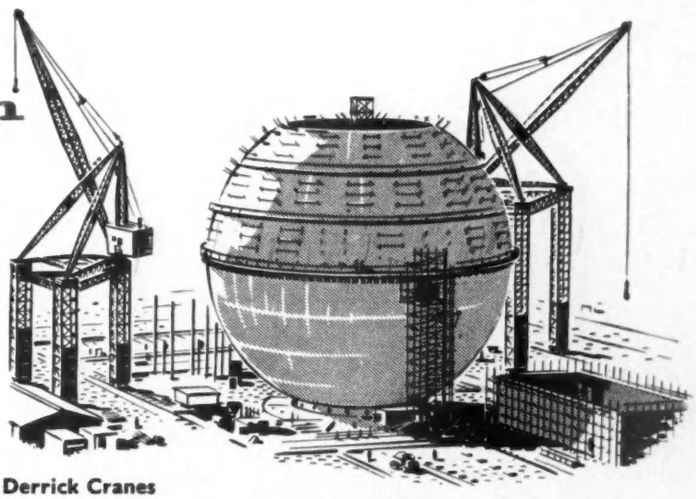

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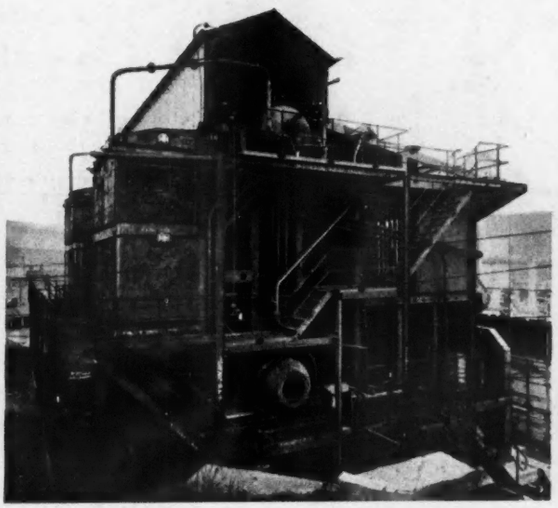
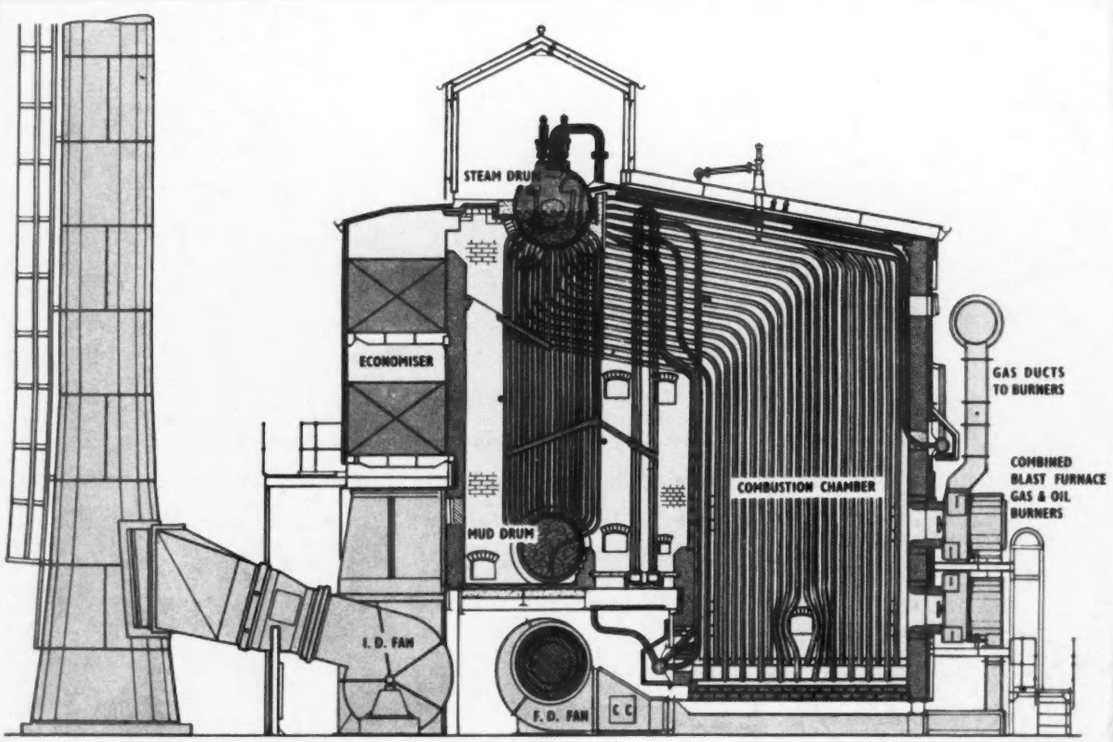


Below is shown the arrangement of a John Thompson 'Integral' boiler fired by blast furnace gas or oil at Messrs. Stewarts and Lloyds, Bilston. Above, one of the boilers is seen during erection.



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